BRAIN AND PERSONALITY

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OR THE PHYSICAL RELATIONS OF THE BRAIN TO THE MIND

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CHAPTER I

HISTORICAL INTRODUCTION

There is no more interesting subject in science than the physical conditions under which we become thinking beings. Though science is concerned with the knowledge which comes from investigation and experiment in the physical world, yet she cannot evade being questioned about the relations of matter to mind, because the bodily organ of the mind is a thing of physics. Hence however discussion about mind may be waived as pertaining to the province of metaphysics this cannot be done with that collection of matter which is called the brain. In it mind and matter come together, and there-

fore we cannot help asking how much the one is dependent upon the other.

As far as the mind is concerned, it must be admitted that no study of its own operations can give the least inkling on this question, any more than a study of the words of a telegram would reveal how a wire came to conduct them. The passage of thought in the one case and of words in the other are equally invisible. But the wire can be followed up until it connects with a mechanism which generates the words for the wire to transmit. Can any analogous result be expected from an examination of the physical mechanism through which the mind acts?

The answer is that something of the kind seems to be assured by modern discoveries of definite relations between particular portions of brain matter and thought. That there are certain material seats of purely mental functions in the brain is now demonstrated beyond mistake by the fact that when these are physically disorganized their spe-

cial mental functions are forthwith abolished, though all other places in the brain remain intact.

It is significant, however, that these discoveries relate in the first instance to the working of the brain of Man in distinction from the brains of animals. Restricted to the brains of animals which they could experiment with, physiologists would have been but little able to determine what special relations the brain held to thought. But with the brain of man it has proved to be wholly different, because, unlike animals, man possesses a faculty which is directly related to thought, the great faculty of speech, and the specific anatomical seats of speech have been found in the human brain as certainly as the ticker is found in its place in a telegraph office.

It should be remarked, however, that it was reserved for physicians and not for psychologists to light upon these great discoveries by their observing what may be

termed the effects of experiments with the human brain which disease makes for them.

While it has been a distinct gain for psychologists to leave metaphysics and turn their attention to the general physiology of the nervous system, the criticism may be made that apart from the human brain the field of psychology is very limited as far as the relation of mind to matter is concerned. A single very circumscribed injury to a place in the human brain may teach more on this subject than a survey of the whole domain of nervous physiology in animals. This is well illustrated by the fact that the identification of speech centers in the brain ere long led to the discovery, again by medical men, of the material seats of a whole series of other faculties both sensory and intellectual; so that taken together these findings give to the subject of the physical relations of the brain to the mind an entirely new aspect.

These discoveries, however, have all been made within the lifetime of our own genera-

tion. On that account they are scarcely known to the general public, and their important bearing on the old question of matter and mind is even less appreciated. Few persons are aware how slow the progress of knowledge has been of the actual physical relations of the mind to the body, and hence an historical review of that progress would seem to be a fitting introduction to our present discussion.

Thus the word brain does not once occur in the Bible, for the good reason that during the centuries in which its different books were written scarcely any one in the world suspected that this most silent and secluded of organs had anything to do with thought or feeling. With the Hebrews, the heart was the chief seat of the soul, while the mind was located in the kidneys, and all tender emotions in the bowels. Thus, one psalmist says that "His reins [kidneys] instruct him in the night seasons"; and another that "The Lord trieth the heart and the kidneys."

The prophet Jeremiah denounces the hypocrites of his day, who "had the Lord in their mouths, but not in their kidneys." In keeping with similar expressions in the Old Testament St. Paul speaks of "bowels of mercies." A survival of these conceptions is found in our English phrase, "Two fellows of the same kidney."

Nor for a long time were the ideas of the Greeks on this subject much nearer the mark. It is true that Plato assigns the supreme seat of the mind to the brain, but how purely speculative were his views is illustrated by the following quotation:

"The creation of bones and flesh was in this wise.

"The foundation of these is the marrow which binds together body and soul, and the marrow is made out of such of the primary triangles as are adapted by their perfection to produce all the four elements. These God took and mingled them in due proportion, making as many kinds of marrow as there

were to be hereafter kinds of souls. The receptacle of the divine soul He made round, and called that portion of the marrow brain, intending that the vessel containing this substance should be the head. The bones were formed by sifting pure earth and wetting it with marrow. It was then thrust alternately into fire and water, and thus rendered insoluble by either. As the bone was brittle and liable to mortify and destroy the marrow by too great rigidity, He contrived sinews and flesh, the first to give plasticity, the second to guard against heat and cold. Having this in view, the Creator mingled earth with water, and mixed with them a ferment with acid and salt, so as to form pulpy flesh, etc." [1]

It is evident that Plato in this confounded the substance of the brain and of the spinal cord with the marrow of the bones, and thus got his conception of marrow as the foundation of the living body. But his younger contemporary, Aristotle, circ. B.C. 335, who was

[1] Jowett's Translation, vol. iii., pp. 339 sq. 362.

the foremost physiologist of his day, and himself the son of a physician, scouted all this vital farrago of Plato's, and as Plato evolved it all out of his own head, without troubling himself about facts, he had little difficulty in doing so. Aristotle examined the brain for himself, and came to the conclusion that its function had nothing to do with mind, but that it was a cool organ which properly refrigerated the blood for the heart!

We may be tempted to smile now at this conclusion, but Aristotle was no mere theorist, and he reasoned according to a sound scientific method from facts as he knew them. We must put ourselves in his place, with nothing to go by more than certain patent facts of life, the explanation of which by other facts was then unknown to him. He found the brain an apparently insensible and inexcitable organ, while the heart was extremely excitable. He therefore only followed his great predecessor Hippocrates, the Father of Medicine, who, recognizing

how quickly consciousness is abolished by loss of blood, or deranged by blood poisons, or by the heated blood of fevers, inferred that the conscious mind resided in the blood, and hence that the heart, as the central organ of the circulation, was itself the chief seat of the soul.

Another cause of misunderstanding was that, as the arteries are found empty after death, owing to their contractile walls expelling the blood from them, it was concluded that these vessels carried air or ethereal spirits from the heart to the rest of the body. We shall see that nothing so contributed to delay for centuries all progress as this mistake, by its suggesting the existence and all-pervading power of vital spirits.

Supported by such great names as Hippocrates and Aristotle, these beliefs held sway for fully five centuries, along with speculations how from the blood the different organs of the body, such as the stomach, liver,

spleen, intestines, etc., elaborated each its share of the various appetites or emotions.

Meanwhile, in this wilderness of Greek speculation, a voice had been crying in vain the true doctrine about the brain long before Plato or any of the rest. Alcmæon, the Pythagorean of Crotona, who lived about B.C. 500, a man who was both an anatomist and an experimental physiologist, taught that the brain was the sole seat of the mind and the source of feeling and of movement, and that at the brain arrived all sensation by means of the nerves. It is evident that he was led to do this by noting that severing the optic nerves leading from the eyes to the brain produced total blindness. Unfortunately he called the nerves tendons, a term which, with its erroneous suggestions, continued to be applied to them for two thousand years, until finally the great Descartes demonstrated the essential difference between tendons and nerves. (Even Shakespeare when he spoke of nerves meant sinews.)

But whether from Alcmæon's colonial origin, or because he was far in advance of his time, both Plato and Aristotle, who must have read his works, alluded to them contemptuously as "somebody's" views. Aristotle, indeed, taught that the spinal cord had nothing in common with the brain, and evidently paid little attention to its "tendons" or nerves.

In progress of time a great school of anatomists and experimental physiologists arose in Alexandria, of whom Herophilus, circ. B.C. 300, and his contemporary, Erastistratus, were the chief, who carefully dissected the brain and traced to it the nerves of the special senses, as Alcmæon had done. They went so far as to divide the nerves into those of sensation and of motion, though they were still hampered by Alcmæon's term "tendon," and apparently they could not wholly shake off the authority of Aristotle as to the functions of the brain.

They prepared the way, however, for Ga-

len, circ. A.D. 160, to whom we are chiefly indebted for the overthrow of Aristotle's doctrine about the brain, and the demonstration of its exclusive title as the seat of thought and feeling. To this great physician belongs the distinction of establishing this doctrine for all time. A contemporary of his, Aretæus of Cappadocia, circ. A.D. 170, advanced so far as to recognize correctly that the brain dominated the muscular movements of the body by nerves, which, originating in the brain, crossed their tracts below in the form of the letter X, so that injuries in one hemisphere of the brain paralyzed the muscles of the opposite side of the body, while if they occurred in the spinal cord below the medulla, the resulting paralysis was on the same side with the injury. But even Aretæus held that the seat of the soul was in the heart.

After Galen the progress of discovery of the true functions of the brain was extraordinarily slow. From the middle of the second

century A.D. to the middle of the nineteenth century, or 1,700 years, the actual gains in this knowledge were relatively most insignificant compared with the splendid advances in astronomy, geography, physical science, chemistry and geology. It would seem as if "to know thyself" scientifically rather than metaphysically, instead of being the first was destined to be among the latest of human achievements.

One great cause for this backwardness was the persistent sway of teleology in all questions about life. Men were ever trying to explain the reasons of things by the imagined purposes of things, and to find the causes in the purposes. Thus we have seen that Plato's whole physiology originated in what he fancied the Creator and the gods intended when they made this or that part of the living body. And all the long way down the centuries we meet with examples of reasoning on these subjects not unlike that of the philosopher who admired the benevolent wis-

dom of Providence in arranging that large rivers should flow past large towns.

One of the greatest of these hindrances was the conception of the brain as a secreting gland, which dates from Hippocrates and continues down to Karl Vogt, Cabanis, and other writers in the earlier years of the nineteenth century, who maintained that the brain secreted thought just as the liver secretes bile. Hippocrates writes that: "The brain resembles a gland, being white and soft like glands. It discharges the same glandular offices as regards the head. It rids the head of its humidity, and returns to the extremities the surplus of its flux." With this postulate, that it is a gland, one authority after another attempted to represent the brain's secretion as a kind of subtle fluid termed "animal spirits," which permeated the body through the blood. Thus Descartes taught that the left ventricle of the heart separated these animal spirits, which had been generated in the brain, and distilled them out

of the blood into a "very living and very pure flame," and then distributed them through the arteries. These animal spirits, therefore, were readily made to account for everything, normal and abnormal. Hence, it was due to noxious vapors and humors that every variety of bodily disorder took its rise.

To illustrate how effectually such conceptions served to block all progress in the science of life we may quote one instance from a ponderous volume in my library with the date 1618, on "Physiology and Anatomy," by Hilkiah Crooke, Physician and Professor on Anatomy and Chirurgery to His Majesty, James I.

Speaking of the origin and growth of hair, he says: "The immediate matter of the haires is a sooty, thicke, and earthy vapour, which in the time of the third concoction [distillation] is elevated by the strength of the action of naturall heate, and passeth through the pores of the skin, which heate exiceateth or drieth this moysture of these sootie and

thicke vapours, for the vapour being thicke, in his passage leaveth some part if it selfe, to wit, the grossest, in the very outlet, where it is impacted by a succeeding vapour arising where the former did, is protruded and thrust forward, so that they are wrought together in one body. The straightness of the passages of the skin where through the matter of the haires is auoyded, formeth them into a small roundness, even as a wyre receyeth that proportion whereof the whole is, where through it is drawne.''

One great office of the hairs of the head, therefore, Crooke perceived to be to lead off "the vapours which otherwise would choke and make smoaky the braine,'' though how hopelessly choked the brains of all bald heads hence would be he does not mention. Crooke's illustrious contemporary, Lord Bacon, held that the blood did not distend the heart, nor cause it to beat, but that was done by its contained spirits. Even Harvey's discovery of the circulation of the blood did not

dislodge these pure nonentities from the brain, for we find as late as 1824, Dr. J. Mason Good, in his "Study of Medicine," mentioning the fact that the brain being a gland, the nervous power or energy issues from it as a fluid of a peculiar kind, and is so distributed by its nerves.

It was the introduction of the microscope into the investigation of nervous tissues which first really exorcised the "animal spirits" from the medical world. Their objective existence in fact had often been called in question before, but it was difficult to banish these airy creations altogether until some solid physical facts could be found which would dispose of them.

Without the microscope we could never have known what every living texture really is, nor after what fashion it is constructed. With the microscope Ehrenberg made in 1833 the first discovery of a nerve cell in a spinal ganglion, and four years later Purkinje demonstrated that the gray matter of the cere-

brum and of the cerebellum is made up of nervous cells and their fibers. This was followed in the next year by the publication of the great work of Schleiden and Schwann, in which they proved that all vegetable and animal tissues are made up of cells and the products of cells. The intimate structure of all tissues and organs was thus revealed, and each was found to be perfectly characteristic of its kind, whether bony, tendinous, glandular, muscular, nervous, etc. Nervous tissue especially is very peculiar and unlike anything else in the body, and least of all like glandular tissue. The brain, therefore, was thus shown to be no more a gland than a hand or foot is, and that it never secretes anything. The brain instead is a special and distinct organ, connecting with nothing but nerves, acting and acted upon only through nerves or nervous masses, called ganglia, which are distributed through the body.

It was not long before this conception of

the brain as a separate mechanism in us, constructed after its own pattern, began to give rise to a new batch of theories. Gall—to whom brain anatomy owes a good deal, particularly in the tracing of the course of the brain fibers down through the medulla oblongata—regarding the brain as one organ, conceived that its convolutions served to mark it off into so many compartments, each with its distinctive mental functions which he proceeded to identify. He thus made out a list of twenty-four brain localities possessed with special intellectual or moral attributes, and which his pupil Spurzheim increased to thirty-eight. Now as all individuals have their personal peculiarities of mind and of disposition, these, in turn, could be explained by the development of their corresponding convolutions. Thus, a mathematician would have a highly developed mathematical convolution, and a combative man would possess his brain seat of combativeness, etc. This so-called science of phren-

ology had great vogue for a time, owing to its further assumption that the outer contour of the head corresponded to the arrangements of the convolutions within, and thus afforded a ready physical basis for estimating what manner of man or woman each person was. So popular became this supposed scientific standard of individuality, that I once heard a prominent clergyman remark that before he addressed a young man about his soul he wished he could be allowed to feel his "bumps."

But as in the case of animal spirits, so phrenology had to disappear before facts. It was shown that Gall and his followers did not study a sufficient number of brains, because, on the one hand, their mathematical convolutions were found as largely developed in the brains of paupers, dying in hospitals, as in the few mathematicians whose brains Gall had investigated; while the brains of some eminent men had no specially developed convolutions where they ought to have had them.

On the other hand, while the inner table of the skull corresponds in a general way with the subjacent convolutions, it does not keep shape with any special convolution whatever; while as respects the outer table of the skull there may be no correspondence at all. Phrenology, therefore, gradually became the exclusive property of popular lecturers, who illustrated its doctrines with plates of variously labeled heads.

The period between 1845 and 1860 was marked by notable advances, not only in general physiology, but also in the physiology of the brain and of the nervous system. The great principle of reflex action, that is, of the afferent and efferent elements in all nervous processes, was established, and many of the amazingly intricate paths of nerve fibers in the spinal cord and in the brain were traced out. France at that time took the lead in all branches of medical science, and the names of Majendie, Longet, Flourens, Gratiolet, and others like them will always rank high in the

annals of neurology. It is not easy at this day to appreciate what a paramount influence was exerted in the medical world by this school of Paris, whose lecture rooms were crowded by students from all countries.

But, partly as a reaction from the doctrines of phrenology, all separate localization of functions in the brain was strongly denied, while the opposite and no less erroneous teaching was promulgated, that the brain always acts as a whole. The cerebral convolutions were regarded as the "sensorium commune," and, as one of them expressed it, "any specific vibration initiated in each kind of sensory nerve thrills throughout the whole or greater part of the mass of the brain." Thus medical opinion seemed to settle down to the conclusion that our two brain hemispheres corresponded to our two lungs, in the respect that every part discharges the same functions with the rest.

But a great change was impending. On April 14, 1861, an eminent French hospital

surgeon, Paul Broca, read a paper before the Société d'Anthropologie of Paris, in which he adduced evidences to prove:

That there is a definite locality in the brain which is the sole seat of articulate speech, found in a limited area in the lower and posterior part of the convolution called the third frontal and which is now named "Broca's convolution." This fact, of course, could only be demonstrated by injuries to that part in the human subject, and Broca showed, by citing a number of post-mortem examinations of persons dying after paralysis of the right side of the body, usually due to apoplexy and who with the onset of the paralysis lost the power of utterance—that in all such cases damage to that locality was demonstrable. As this statement seemed at first to be a reversion to the tenets of phrenology, it gave rise to so much heated discussion and denial, that it was not until about 1865 that it began to be generally admitted.

What chiefly led to its final acceptance was

the further discovery that the two other elements of human speech besides articulate utterance also have each their distinct and separate brain localities; one place being found for the words we receive through the ear, damage to which place causes *word*-deafness, even though there be no deafness to other sounds than words; and, secondly, one place for words received through the eye in reading, damage to which causes the subject at once to become wholly illiterate, though he may see and recognize all other objects of sight, except words, as well as ever.

The demonstration of these anatomical bases of the faculty of speech soon led to careful experimental investigation of the brain in animals for other seats of distinct functions, constituting what is now termed cerebral localization, and to a comparison of the results achieved with the effects of injury or of disease in the brain of man. By 1870, through the labors of both experimental physiologists and practicing physicians, such as Hitzig,

Ferrier, Munk, Luciani, Charcot and others, it was shown that each of the special senses has its anatomical seat in the brain; and, in addition to that, in a centrally placed zone are to be found the seats governing the voluntary movements of the muscles of the body, so that each muscle, or group of muscles, can be made to contract by excitation of the corresponding locality in the cortex or surface of the brain.

These discoveries were great enough of themselves, but they are relatively of secondary importance compared with those which followed and which will cause the name of Broca, as yet scarcely known by the general public, to rank in the history of science along with the names of Copernicus and of Isaac Newton. The anatomical seats of the senses, and those of muscular movements, are found equally in both hemispheres of the brain, and their functions, as such, are doubtless congenital. It was thus natural to infer, as the brain is a double organ, like our

two eyes and our two ears, each hemisphere being the duplicate of the other, that both brains would equally participate in all brain work.

But a most unexpected fact, and one of far-reaching significance, was soon demonstrated, namely, that the anatomical seats of the faculty of speech are found only in one of the two hemispheres. Thus, if the Broca convolution, which is the seat of articulate speech, be damaged in a person after middle life, the loss is usually irremediable, so that he can speak no longer though the same convolution in the other hemisphere be wholly intact. The same is true as regards word-deafness or word-blindness from injury of their respective places, for the corresponding localities in the other hemisphere, though not hurt at all, nevertheless are entirely word-deaf and word-blind, simply because they never had anything to do with speech.

But here again another new element in the problem presented itself, which proved that

the endowment of one hemisphere with the great gift of speech was not owing to any original or special fitness of that hemisphere for such a function, but solely because it was the hemisphere related to the most used hand in childhood. In all right-handed persons, it is in the left brain that the speech centers are located; while in left-handed persons, they are found exclusively in the right brain.

Two conclusions inevitably follow upon these facts, first, that brain matter, as such, does not originate speech, for then both hemispheres would have their speech centers; and second, that either of the hemispheres is equally good for speech, if something begins early enough in life to use it for that purpose. That something is the most commonly used hand by the human child at the time when it is learning everything, for self-education always begins in our race with the stretching forth of the hand, as any one may note in the first purposive actions of an infant. The

hand which it then most used to learn by determined which of its two brain hemispheres should know speech, and which hemisphere should remain wordless, and therefore thoughtless, for life.

This latter statement, that thought, as such, is a function only of the hemisphere connected with the faculty of speech, was decisively demonstrated by the next revelation which followed upon Broca's fruitful discovery. Without any help from metaphysics, and upon a much surer basis than any metaphysical theories, it was simply found as a physical fact that our mental faculties, as such, are quite distinct from the elementary functions of sensation and of motion. These latter are congenital, but our ability to recognize and, therefore, to know what the particular objects or meanings be of what our senses report, is not congenital, but as much acquired by us as our speech is acquired and not congenital. Because, connected with the original anatomical seats of sight and of

hearing were found certain physical, anatomical areas of brain matter, injury of which abolished all power to recognize what the eye sees or the ear hears. In the visual area is a place which, if damaged, renders the person unable to recognize members of his own family, though he see them; and in the auditory area are places, one of which, if hurt, causes the person to be no longer able to know his most familiar tunes when he hears them; while, by injury in another spot, he loses all power of distinguishing sounds in general, so that he cannot tell the bark of a dog from the song of a bird, because they are alike only noises to him. And here again, these important brain areas in us, interpreting what sights or sounds mean, are found only in the left hemisphere of the right-handed, and in the right hemisphere of the left-handed; in other words, in the hemisphere in which the seats of the faculty of speech are located.

The decisive bearing of these pure mat-

ters of fact upon our whole discussion of the Physical Relations of the Brain to the Mind and to the Personality is plain enough. As none of these wonderful mental faculties, including that of speech, were connected with brain matter at birth, but were created afterwards, it follows that they were created by the individual himself anatomically modifying his own brain. That brain matter did not itself organize these physical areas of mental function is shown by their entire absence from the convolutions of the wordless hemisphere.

As these physical relations of the brain to the mind are to be fully discussed in our succeeding chapters, we would have preferred not to have alluded to them so far in advance, and we have done so now only for this reason. Many persons may imagine that such a theme must involve a discussion of what the mind is, and, therefore, enter upon the wide domain of metaphysics. We propose to avoid anything of the kind, as our subject deals pri-

marily with a thing of physics, namely, the brain. But the main facts about the structure and working of the brain are of such recent discovery that they scarcely yet have become generally known, at least in comparison with the latest discoveries in the physical sciences. Regarded, however, simply as matters of knowledge, these new additions to our information about the one organ in us which is related to thought can be second to none in interest and importance.

CHAPTER II

ACCOUNT OF THE PHYSICAL BASIS OF THE MIND

Two fundamentally opposed conceptions have existed about the relations of the Brain to the Mind, which may be illustrated by comparing the brain to either one of two different instruments or mechanisms for producing music, an Æolian harp or a violin. Thus, if the brain may be regarded as an organ from which thoughts proceed, the question then becomes, Do thoughts arise in it as musical sounds flow from an Æolian harp or as they come from a violin?

Both the Æolian harp and the violin are constructed by threads of catgut stretched over apertures in a wooden box. The music of the Æolian harp comes from it when it is placed where currents of air can flow through its threads, and its notes will then vary ac-

cording to the direction, the strength and the velocity of the currents. The air which generates the music is a part of the whole outside atmosphere, and while each harp has its own peculiarities of size, number of threads, position, etc., its function source has no peculiarity, but is one and the same in all. In like manner, some hold, currents of thought are excited in the brain by the incoming sensations transmitted from without by the vibrations of the various nerve fibers which are specially adapted to receive impressions, and these vibrations in turn awaken those responses among the fibers and cells of the brain which constitute feelings and ideas.

On this view a man's brain may be regarded as a specially constructed mechanism whose individual peculiarities in its working, as shown in his daily life, are all due to the arrangement of its material component parts. Some lives give forth long, rich, harmonious notes throughout; others, from unhappy dis-

position of their fibers, give forth little else than prolonged discords; and others a strange mixture of both; but all these individual, or so-called personal characteristics are matters of cerebral structure, as this is acted upon by the innumerable nerve stimuli proceeding from the outer world. More or less defined conceptions of this kind about the relation of the brain to the mind are quite prevalent, particularly among those who emphasize the influence of heredity in the genesis of individual or moral traits. The logical conclusion of this position is, that the mind on the last analysis is the product of the composition and properties of brain matter, and its operations of whatever sort are reactions among the brain elements to the play of external forces.

The other and essentially different conception is that the brain, if likened to a musical instrument, resembles a violin in that, however good it be as a musical instrument, and however carefully it has to be constructed in

all its parts to become such an instrument, yet of itself it cannot give forth a musical note, much less take part in a complex symphony, without a musician to use it. Therefore, though no musician can give us violin music without a violin, so no violin can be musical without a musician. It should be noted that this theory requires mechanism, and the complete integrity of the mechanism, quite as much as the other. In fact, the musical vibrations within the box depend so much for their qualities upon the wood out of which the violin is made that extraordinary sums have been paid for a Stradivarius on that account alone. But though mechanism be such an essential element in both, the entrance of a wholly different factor in the case of the violin, namely, the musician, makes it impossible to harmonize the analogies to brain function drawn from these two instruments. In the one we have only the effects of external forces acting upon material things; while in the other we likewise have

material things, but the effects come from a source entirely distinct from and wholly independent of them. We only need now to follow up each of these views to their inevitable conclusions to recognize how far apart they are. The one regards the mind as wholly of the brain, and hence the mind can have no existence apart from the brain. The other regards the brain as nothing more than the instrument of the mind, and no instrument can possibly be identical with the agency which uses it.

As the brain itself gave not the least sign of its activities, so much so that, as already mentioned, the world for ages did not suspect that it had any connection with thought or feeling, it was natural that the discussion should center first about the terms mind and body. As regards the mind, the processes themselves of thought appeared to offer in their genesis and sequence the only elements for examination. Metaphysicians, therefore, have labored at the problem for centuries,

but without coming to any agreement, one chief reason for their failure being that in their methods of investigation they have had to rely upon introspection. But the difficulty with introspection is that it is like a man trying to lift himself by his own boot straps. As our mental processes both begin and end within ourselves, they offer little which is objective for us to go by. We need instead some external fulcrum to draw upon for satisfactory inferences.

Such a fulcrum seems at last to be promised to us by modern discoveries connected with the brain itself in its relations as an organism to certain definite mental functions. This was not possible so long as the brain was regarded as a single organ working as a unit, with the same relations in all its parts to consciousness and thought that the air cells wherever located in the lungs bear to respiration. Looked at thus, the physiologist with the brain before him was even worse off than the metaphysician, for nothing could be

more undemonstrative to mere inspection than healthy brain matter. Physiologists, therefore, were obliged to investigate the brain, bit by bit, to find whether some parts of it were more connected with certain psychical functions than others. After the most extensive experiments were made on the brains of living animals, certain important facts were demonstrated which have most direct bearings on the problem. Moreover, these experimental deductions have been further confirmed by observations of the effects of local brain damage caused in man by injuries or disease. By these means it is now proven that the gray matter of the brain surface is specially arranged to subserve certain specific psychical functions only in certain localities in its substance. It is not the whole brain which sees or hears, but only particular limited areas to which the consciousness of sight and of hearing respectively are confined. Likewise the voluntary movements of each group of muscles in the body have

been found to proceed from certain well-defined starting points on the brain surface, and these are so well demonstrated that the surgeon often knows, by noting what muscles are implicated, just where to open the skull with his trephine so as to find the lesion or injury in the brain.

On these grounds the inference seems probable that every special psychical function is subserved by its own special seat in the material organ of the mind. Hence, by these discoveries we do seem to have come into possession of really objective facts where before everything was subjective; because nothing could partake more of the nature of an objective fact than the identification of an area of brain matter with a given brain function, by that function becoming invariably impaired according as its brain place is damaged.

We propose, therefore, to discuss in the following pages the bearing which these now demonstrated relations of brain structure to

mental operations have upon the two opposite views above stated of the relations of the brain to the mind.

Fortunately for the general reader, the essential facts bearing upon our present discussion can be readily demonstrated and easily understood. All are agreed that as far as the brain is concerned, the gray matter of the brain surface, technically called the cortex, is the ultimate seat of all processes connected with sensation and thought. This gray matter consists of a continuous layer, whose average thickness is from one-twelfth to one-eighth of an inch, of a soft material of a very complex structure, in which are imbedded immense numbers of little bodies, of various shapes and sizes, unfortunately called "cells," for they are not hollow. Between these cells ramifies a network of innumerable fine gray fibers. To save space this layer of gray matter is everywhere folded upon itself, as one would crumple up a handkerchief in his hand, so that the sur-

face of the brain presents a number of furrows or creases between the folds. The chief furrows, however, are quite definite in their location, so that the main folds are called lobes, and the smaller ones convolutions, and these in turn serve to map out the different regions of the brain surface which are then named accordingly.

Underneath and within the gray layer, and constituting the greater part of the brain mass, is the white matter, which consists of bundles of gray fibers contained within sheaths of apparently an insulating material and white in color. Some gray fibers, however, have no coating. The function of a nerve fiber is wholly that of a conductor to and from the gray matter. On that account the white matter is not, like the gray matter of the surface, the primary seat of any mental power, though in many instances these fibers form important links between the various cortical areas which seem to promote associated actions between them.

Here, therefore, in the gray matter of the surface of the brain we have a material substance which is the definite seat of the conscious mind. For, as just stated, if one particular area of this gray layer be destroyed, sight is totally lost, though the eye itself in all its parts, with the nervous tract leading therefrom to the brain, be wholly intact. If another particular cortical area is similarly injured, hearing is abolished, though the ear with all its apparatus be uninjured. The consciousness of sight or of hearing, therefore, is neither in the eye nor ear respectively, but in these special localities on the brain surface. To use the phrase of an old anatomist, the gray matter is the animal. Regarded thus, this form of matter is the most interesting and important substance in the world, for it is the only matter which we know of that is directly associated with mind.

There can be no question also that upon the integrity of this gray matter depends the integrity of all mental processes, for

these can be proportionately perverted by anything which interferes with the physical conditions of the gray tissue, or by agents which derange its working. Thus mechanical injuries of the brain in man often have been followed by peculiar mental disorders, sometimes including change in disposition or in moral character.

The most striking illustrations of this kind, however, and which can be produced at will, are furnished by the action of brain poisons. In fact a curiously interesting treatise might be written with the title of the "Metaphysics of a Drug Store." Thus, opium powerfully stimulates those mental processes which are related to the imagination, so that the opium taker becomes intensely interested in his own trains of suggested ideas. He is therefore silent and solitary, and thus contrasts with the alcohol taker, who has his feelings and emotions so stimulated by that poison that he would fain share them with other persons, and becomes both familiar

and talkative. One of the most singular in its effects on the mind is haschish or Indian hemp. When fully under its influence, the haschish smoker can be made to entertain a most vivid sense of the objective reality of any suggestion which is made to his fancy. I once knew a party of Arabs who, while all drunk together with this drug, came to an opening in an over-arched street in an Oriental town through which the moonlight streamed upon the pavement. The leader of the party took the moonlight for a pool of water and forthwith drew up his trousers to wade carefully through it, and was followed by all the rest of them doing the same thing.

Hence, by merely introducing certain definite substances into the blood stream, as it rapidly courses through the brain from its four great arteries, we can produce well-defined mental processes characteristic of the operations of these agents; or, in other words, sensations, feelings and ideas specifically generated by these wholly material

things. In time also the persistent use of these agents seems to alter the personality itself. Thus, a confirmed drunkard finally becomes more unlike his former self than an average European differs from an average Asiatic.

At first sight such facts as these seem to indicate that the brain and mind are one. Change the state of the brain, and the thinker is changed accordingly. It is not surprising, therefore, that previous to the progress of discovery within the last twenty-five years, it appeared as if nothing could be postulated about mental phenomena apart from the material condition of the mind's organ. The Æolian harp theory that sensation and thought are the products of vibrations through a specially arranged mechanism, seemed to correspond most naturally with the facts.

But unfortunately for this conclusion, all the facts adduced in its support can be adduced just as conclusively in support of the

opposite theory of the brain being but the instrument of the thinker, as the violin is the instrument of the musician who plays upon it. The most skillful violinist would draw forth nothing but crazy sounds from his instrument if its cords were smeared with grease instead of with rosin, and every mental disorder from delirium to coma can be paralleled by corresponding musical derangements due to purely structural conditions in the violin itself, and not at all in the performer. It then would be from no fault of his, but solely from conditions in his instrument that every sound which he can get out of it is faulty. Indeed, the rightful director of thought may often appear to be striving to regulate the brain of a drunkard, just as a musician would deal with a disordered instrument; and still more strikingly do we see something akin to this in certain states of insanity.

We are thus left by these considerations just where we were before; and hence we

must go further and deeper than physical changes in brain matter can take us to arrive at satisfactory conceptions of the true relations of the brain to the mind.

CHAPTER III

BRAIN WEIGHT AND MENTAL FACULTY

What we have arrived at so far is that the gray matter is the physical basis of the mind. No one now disputes this. The eye does not see any more than an opera glass sees. It is one place only in the gray cortex which actually sees. And as with the consciousness of sight, so doubtless the seat of every other special form of mind consciousness is somewhere in this mysterious layer. But how far does this take us?

Not very far, because if we hence should infer that consciousness in all its forms of sensation, feeling, perception, thought, etc., depended wholly on the existence of so much gray matter, we should soon encounter a series of material, *i. e.,* physical, facts and conditions which, if they did not actually con-

tradict such inferences, would at least seriously modify them.

To begin with the simplest as well as the most physical facts. In all animals there is a close correspondence between the degree of development of any organ and its functional power or activity. A powerful arm implies a big arm, or at least not an undersized one. Is a powerful brain likewise a big brain, or at least not an undersized brain? In other words, does the actual size of brain in man bear any direct relation to mental capacity? This question may be answered in the affirmative, only, however, with so many qualifications that it then becomes by itself of little account in our discussion. Thus the brains of most idiots and of half-witted persons are usually smaller and weigh less than the average of normal brains, while many men distinguished for their mental powers have had large and heavy brains. But the exceptions are very numerous both ways. Thus, assuming the average weight of normal European

brains among men to be 49.5 ounces, we have the following list of the brain weights of distinguished men given by Prof. John Mar, shall:[1]

Abercrombie	64.7
Lord Campbell	56.7
Webster	55.5
Chalmers	54.8
De Morny	54
Whewell	51.2
Grote	52
Tiedmann	47.4
Hansemann	45.4

The last two, a distinguished physiologist and a mineralogist, were below the normal. But just such variations are found among people in general not at all distinguished. Even among paupers, in a large series of observations cited by Professor Marshall, thirteen brains among nine hundred were found to weigh above sixty ounces. The

[1] Jour. Anatomy and Physiology, 1892–1893, vol. xxvii., pp. 21–65.

heaviest, perfectly healthy brain was that of a mechanic, which weighed just above seventy ounces.

In the Journal of the Biometrical Society, June, 1905,[1] Prof. Karl Pearson, F.R.S., and Dr. Raymond Pearl give the results of an analysis of 2,100 adult male and 1,034 adult female brain weights, belonging to five races—Swedish, Bavarian, Hessian, Bohemian and English—with the conclusion that "There is no evidence that brain weight is sensibly correlated with intellectual ability. Of the five races investigated by the biometricians, the English have the smallest mean brain weight. The mean of the adult Englishman is 27 grams less than the Bavarian mean, 57 grams less than the Hessian mean, 65 grams less than the Swedish mean, and 120 grams less than the Bohemian mean."

On the other hand, brain bulk as such varies according to racial peculiarities, with

[1] Nature, Dec. 28, 1905, p. 200.

little or no reference to mental faculty. Thus the ancient Peruvians, who founded the empire of the Incas, must be regarded as an intellectual people, but they were remarkable both for the small size of their skulls and for brains which were on an average no larger than those of many idiots.

One of the latest discussions on this subject is by Prof. David Hansemann,[1] who made a most careful examination of the brain of the most remarkable man in modern times for pure intellectual powers, Hermann von Helmholtz. Prof. Hansemann was much disappointed to find that Helmholtz's brain weighed barely 45 ounces. But the brain of Dr. Dollinger, the eminent historian, weighed only 37.7 ounces. He concludes his elaborate paper on this subject with the remark, that all investigators agree that the weight of the brain bears no relation to the mental capacity of man. Likewise the external

[1] Ueber das Gehirn von Hermann von Helmholtz von Professor David Hansemann. Zeitschrift für Psychologie und Physiologie der Sinnesorgane, 20. Band. Leipzig, 1899

measure of the head is of no account whatever. No man's intellect can be judged by the size of his hat. Johannes Muller's had the large circumference of 614 millimetres, Richard Wagner's 600 millimetres, but Napoleon's was only 564 and Darwin's 563 millimetres.

Therefore if any conclusions can be drawn from these considerations it would seem as if brain organization was more important than mere size. Hence it follows that neither of our two opposing theories is helped by these anatomical facts. A gifted violinist would greatly prefer to play upon a violin of standard make, however expensive it was, than appear before a critical audience with the cheap product of a village artificer. No one can doubt that an originally well-organized brain is a good thing to have, but that does not affect the real point at issue, which is, whether the best-organized brain, or for that matter any other brain, can be made to think without a thinker.

We have, therefore, again to go further into the subject than the mere size of the brain in man will carry us. But our very next step brings us to an anatomical fact of primary importance, which seems to make our previous discussion about the bulk of brain matter quite superfluous. To some, indeed, this anatomical fact appears to dispose of the Æolian harp theory altogether, as far as a physical basis for it is concerned. So sweeping in reality are the conclusions which follow upon this single material factor in the problem that it is well to pause and take our bearings on all sides to be sure of the full import of its significance.

The question all along has been this. As all are agreed that the gray matter is the material seat of thought, etc., is it also the *source* of thought? The dictum of Bory St. Vincent, Cabanis, Karl Vogt and others, was that the brain secretes thought just as the liver secretes bile. As a statement this is intelligible enough, and all writers who ad-

vocate what we have represented as the Æolian harp theory of the relation of the brain to the mind will be found on examination to hold essentially the same opinion, however they may differ in their statement of details. Thought, feeling, volition, etc., are, on the last analysis, according to any such view, the products of the material organization of the gray matter as it responds to its appropriate specific stimuli.

Now it is evident that such a premise involves one inevitable conclusion, namely, that the more gray matter you have the more thought, etc., you will have. If this be granted it becomes then a question of quantitative gray matter, and if, in accordance with modern conceptions, thought be conceived of as a form of energy stored up by the gray matter, then the amount of this energy liberated will be proportionate to the quantity of the specific substance which stores it up. But even on this hypothesis, mere quantity of the mind-generating material is not enough. An-

other factor has to be taken fully into account, namely, how it is organized, because it is only by its special organization that one portion of this gray matter is endowed with the faculty of sight, and another in a different place does not see but hear, and so on for each special sense. But for the present we may let this inconvenient factor pass, and revert to the original proposition, that however complex the organizing be, it is the gray matter which is organized, and hence the more there be of this cerebral stuff, the more, correspondingly, will its various mental products be.

But the anatomical fact which wholly disposes of this theory is that we, like most people, and particularly these reasoners, are quite inaccurate when we use the word "brain." There is no such thing as *a* brain in a human being. He always has two brains, and never one brain, just as he has two eyes and two ears. And these two brains are just as perfectly matched and duplicates of each

other in all their parts as his two eyes and his two ears are.

Therefore if the quantity of gray matter is the fact for us to found our superstructure upon, one-half of this matter being in the right brain and the other half in the left brain, it follows that if one of the two brains be rendered useless by any chance, either half the mind, or half of the mental capacity will be gone. Is that so?

Instead of being so, it has been abundantly demonstrated that one of the two brains can do all the thinking necessary for the purposes of life. No addition of mental power, nor of mental endowment is secured by our having two brains, any more than the faculty of sight is increased in us by our having two eyes. This, however, is only in accordance, as we shall see, with the general law of all pair organs in the body, whose existence in pairs is for quite other reasons than for increase in function. It is difficult, therefore, to see why our paired brains should consti-

tute an exception to this law; and that they do not do so in fact we shall show by anatomical evidence of the most convincing kind.

We may observe here in passing that this pairing of the mind's organ is a very perplexing problem to some reasoners. As one authority[1] remarks, "We are completely in the dark as to the reason why we possess two hemispheres." This difficulty arises mainly from certain assumptions about the relations of thought to matter, while the constant use of the term brain unconsciously leads to the conception of a single organ as the source of thought, just as the liver is the only source of bile. It is, in fact, an illustration of the dominance of this conception that this identical comparison of the brain to the liver occurs so often among writers of this school. But though we may correctly speak of the eye and of the ear in the singular, as long as we are talking of the function itself—of sight or of hearing,

[1] Sir Michael Foster, Physiology, p. 872, 5th Edition.

such language is no longer correct when we speak of them in the plural, for we then are only referring to them as the instruments of sight or of hearing. For instruments, and nothing but instruments, these pair organs certainly are. Though without the eye there would be no sight, and without the ear no hearing, yet the eye is no more the seat or source of sight than is a telescope or a microscope. Whether, therefore, our two perfectly symmetrical brains are likewise not the sources, but rather the instruments, of thought, we will now proceed to examine.

CHAPTER IV

SIGNIFICANCE OF THE BRAIN BEING A DOUBLE OR PAIR ORGAN

Our brains consist of two perfectly matched organs technically called the right and left hemispheres. As regards their gray matter, they correspond furrow for furrow, lobe for lobe, and convolution for convolution. Now with the partial exception of the hands and feet, the salient fact about other pair organs in the body is this: *That either one of the pair can do the whole business of both* if necessary. It is not one of the two eyes which sees red while the other sees green; nor, if a man knows the two languages, does one ear hear only English and the other only German. What one eye sees, the other sees, so that if a man should lose one eye, with the

remaining eye he might become either an astronomer or a microscopist. Some persons have been known to live for many years with only one lung to breathe with. I once was called in consultation to see a strong workingman who had lived for thirteen years wholly unaware that he had only one kidney, the other having been destroyed by a stone becoming impacted in the tube leading from it, when he had an attack of kidney colic. It was a similar mishap in the tube of the remaining kidney which first showed what his defect was. It is evident, therefore, that the chief reasons why we have pair organs is, first, for convenience, due to the body itself being generally two-sided, right and left; and, secondly, to insure against emergencies, just as a man will provide himself with two keys for the same lock, lest he lose one.

As regards our brains, however, there is one exception to this rule about pair organs, in a division of labor between the two hemispheres, in respect of the control of those

muscular movements which are of a voluntary character, the centers of those governing the right half of the body occupying a tract in the gray cortex of the left brain, while those of the left half of the body are correspondingly located in the right hemisphere. The most probable explanation of this arrangement is that it insures a more perfect balance between the two sides of the body in its muscular movements. Thus the two eyes need to move in most perfect harmony, and on that account there is a special crossing of nerve fibers from side to side to secure this unity of action. But with respect to thought itself the above mentioned law about pair organs holds perfectly.

It has been repeatedly shown by *post-mortem* examinations that persons have lived for years with only one hemisphere in working order, the other having been virtually destroyed by disease; but with the exception of parts in one-half of their bodies being paralyzed for voluntary movements, such as those

of the arms and legs, they have thought and acted and transacted business as well with one-half of the gray matter with which they started in life, *i. e.*, with only one hemisphere, as others are able to use one eye for all purposes after losing its mate.

Of many such instances we need cite only that of a man who for several years was under the observation of an expert neurologist, who published a history of his case with a full description of the conditions found in his brain after death.[1]

The patient had always been strong and well, and was forty-seven years of age, when he awoke one morning with his whole left side numb and paralyzed. He remained thus paralyzed for ten years till he died, but meantime his speech was perfectly normal, his reading good and his memory unaffected. He gave no sign of mental weakness, but was always intelligent, patient, cheerful and particularly good in attention. He read the

[1] Dr. Pearce Bailey, Am. Jour. Med. Sciences, March, 1889

papers constantly, and liked to talk politics. He bore his disability bravely, and was neither depressed, emotional, irritable nor apathetic. At the autopsy a large cyst, full of fluid, occupied the anterior part of the right hemisphere, with the whole tissue disorganized and without any remains of gray matter, while the posterior half of the hemisphere was everywhere atrophied. Microscopical examination of the tissues showed the same destruction of the nerve elements. Dr. Bailey concludes with saying: "Putting all together the man (during life) manifested nothing to indicate that the power of operations of his mind had been affected, and yet after death the whole of one hemisphere was found to be greatly lessened in size, and impoverished in cellular constituents, and the frontal lobes which some regard as the seat of the highest cerebral functions were almost totally annihilated on one side."

On the other hand, there is one anatomical fact which might give color to the supposi-

tion that our two brains are constructed to operate virtually as one organ. At the bottom of the cleft separating the two hemispheres there is a large bridge named the corpus callosum, four inches in length, and which is made up of bundles of white fibers which pass from one brain to the other. It has been supposed that the function of this commissure, as it is called, is to make the various brain centers in the two hemispheres work together, as some of its fibers have been traced from certain areas of the cortex down to this bridge and across it to corresponding areas in the opposite brain. This surmise was apparently strengthened by the frequent absence, or only partial development, of this commissure in the brains of idiots or of feeble minded subjects. But the progress of research has not confirmed the theory that the two hemispheres are functionally united by this connecting bridge. For in cases of mentally defective subjects, where the corpus callosum was found wanting, other organic

abnormalities were also invariably found which had to be taken into account as well. Meantime numerous reports have been published of *post-mortem* examinations performed by distinguished neurologists on persons who during life showed no signs of mental defect, and yet in whom there was no corpus callosum between the two hemispheres. In each of these subjects also there was no other abnormality present in the brain. Most of these cases were only accidentally discovered in the bodies of persons dying from ordinary diseases, because nothing in their antecedent history suggested the existence of their anatomical peculiarity. Thus Eichler reports the case of a man forty-three years of age, "a laborer who during life had showed no mental peculiarities, but was a diligent, capable workman, a good husband, and in every respect sober, quiet and well-behaved, and could read and write," but in whom the corpus callosum was entirely absent. The eminent neurologist, Professor

Erb, in reporting two similar cases, remarks that "when the brain is otherwise well-developed, with absence of the corpus callosum, there may be no disturbance of motility, co-ordination, general or special sensibility, reflexes, speech or intelligence." Considering the rarity of autopsies in which careful examinations of the brain are made, such cases may be quite common in the general population without anything in life betraying their existence. Undoubtedly this connection between the two brains may be of use in providing against some accidents to either of the cerebral pairs, but these instances of its absence only serve to prove that for performing the ordinary functions of mental life, the two hemispheres are wholly independent of each other. Indeed, one investigator of this subject remarks that the problem of the use of the corpus callosum is still unsolved, as its absence appears to be so little missed.[1]

[1] This subject of absence of the corpus callosum is fully treated in an article by the well-known brain anatomist, Prof. Alex. Bruce, in Brain, 1889, pp. 171–9.

The inference from these facts is perfectly obvious. If one-half of the total gray matter of our brains is distributed in one hemisphere, and the other half in the second hemisphere, it is *not* for the purpose of doubling, or even increasing our mental capacity. We might lose one-half of our gray matter, provided the loss is only on one side and the other side remains whole, without losing a single idea thereby. In other words, we might reason, argue, calculate, love or hate, like or dislike, or, in short, be altogether ourselves mentally with only one-half of our gray matter left to us. We, therefore, as persons, do not depend for our personality upon the number of ounces of gray matter which our cranial cavity contains, but rather on the fact whether the gray matter of one of our hemispheres be in good condition or not. If it is, then the gray matter of the other hemisphere is not needed by us for the purpose of thinking. Our gray matter as such is halved, but we ourselves are not only not

halved into two half selves by this bilateral distribution, but we remain the same mental unit as ever if only we can keep intact that one of the two hemispheres which, as we will see later, is the sole seat of thought.

These undoubted facts, therefore, lead to just as undoubted a conclusion, namely, that everything involved in our conscious personality, while related to gray matter, is only related to, but not originated by, gray matter; for if it were originated by gray matter, then both hemispheres would be equally necessary to our complete personality. If a stream of water comes from two equal sources, the drying up of one stream will leave only half the quantity of water running; and just so must the stream of thought fall off one-half when one hemisphere is injured, if it *originates* in the two perfectly equal hemispheres. Or, to put it conversely, if gray matter originates thought, then both our hemispheres must share equally in producing thought, for one has just as much gray

matter as the other, and with just the same arrangement and organization of it.

It is these demonstrated truths which, as we have remarked before, prove so embarrassing to those who hold the view that the brain makes the mind. As one hemisphere is quite enough for all mental requirements, they cannot but regard on their principles the other hemisphere as quite superfluous. So it would be if their principles were valid. If thought is actually a secretion or product of the brain, as bile is a secretion of the liver, then the case with the brain is the same as if we had two fully developed livers which, however, could not be made to produce more bile than one alone does. If our brains are never anything more than the instruments of a thinker, the thinker might very well have two such instruments, and use either one as he chooses.

I have been informed by watchmakers that they grow so accustomed to use only one of their eyes at their work, that in time they be-

come unable to use the other eye for it. We shall see further on that the human thinker likewise becomes so accustomed to use only one of his brain pair for thought that it is doubtful if he ever uses its fellow to formulate a single idea. With which one of the pair he will choose to do his thinking for life depends upon a sort of accident, almost of the nature of a whim, during the days of childhood.

So far we have been gradually approaching the central subject of all our discussion, namely, the relation of the brain to thought. Heretofore we have referred to certain ascertained localizations of brain functions in special places in the brain cortex. But none of these functions yet mentioned are necessarily identical with thinking or thought. A sensation like that of sight is not thought, however much of thought, after its reception, it may give rise to. Likewise a muscular movement in response to excitation of the corresponding area in the cortex is not itself

an act of thought, however it may follow upon thought. Now what is thinking? We are precluded from asking metaphysics to answer this question because our subject deals only with the relations of a thing of physics, *i. e.,* brain substance, to mind. We are called upon instead to answer the question, Are there definite localities in the brain substance which have as close relations to acts of pure thinking as we have found to be the case in connection with acts of seeing or of hearing?

Unlike the metaphysician, who would begin with defining what thought and its elements are, we can only cite concrete examples of thinking done by or through an active human brain. A judge when he takes the briefs submitted to him, and sits down to write out his opinion, is thinking; an orator making ready his oration to sway an assembly, is thinking; an author at work on a book is thinking; a philosopher pondering a subject in philosophy is thinking; and so on. Now

is this mental faculty of thinking so dependent upon the material arrangement of brain gray matter in special localities thereof that, just as physical injury in the cortical sight area may cause total blindness, so a similar injury in these special areas—all other brain areas remaining intact—would make it impossible for the judge to write an opinion, the orator to compose his speech, or the author to go on with his book?

It is even so, and the demonstration of how and why it is so furnishes more data for the correct estimation of the true relation of the brain to the mind than any of the facts which we have heretofore been considering. It has been discovered that certain well-defined areas of the brain cortex minister as directly to human thinking as others do to special sensations or to movements, and when once we appreciate their significance, we must admit that no greater discoveries than these have been achieved in science. We cannot ask to be led higher than to the very seats

where thought becomes articulate, and we may well pause when we find ourselves unmistakably there, to ask what it all means. We have been seeking for the material whereabouts of mind, if such there be, and hence the question whether we can come into the *physical* neighborhood of some great and purely mental faculty cannot but involve the solution of our whole problem. It was indeed a great step to discover just where a sensory stimulus traveling from the outside world along a nerve fiber ends, not only in a physical stopping place, but in a conscious perception. We are, however, far more than conscious selves only. We are thinking selves, and nothing could be more important than to investigate the physical bases of the one transcendent human endowment which is so associated with thought itself that no true thinking is possible in man without its exercise.

CHAPTER V

THE FACULTY OF SPEECH

Before entering upon the consideration of the Faculty of Speech and its bearing upon the subject of our discussion it is fitting to note the fact that no investigation of the human body itself affords the least explanation why man is man. There is nothing in his physical frame which truly separates him from other animals, because every member and organ of his body has its counterpart or analogue in the bodies of other animals. Man shares with other mammalia the same kind of lungs to breathe with; his blood circulates through the same kind of heart and arteries and veins; he digests and assimilates his food by the same kind of apparatus, with all its varieties of parts and accessories; his secreting glands, his muscles, his bones and,

in short, every other bodily thing in him is like unto theirs. Also not only the anatomy, but the physiology, that is, the working of every physical element in man, is so strictly in keeping with that of other mammals that much the greater part of our knowledge of human physiology is derived from investigations into the physiology of other animals. We even deduce from experiments on them how either medicines or poisons may affect ourselves.

But there is one organ of his body which immediately suggests itself as necessarily a great exception to all this. The mind of man; what must its organ be? How could the human brain be other than a most exceptional brain in the whole animal series? This inference seemed so certain that the most diligent search was long continued for the physical counterpart in man's brain to his marvelous intellect. Nothing, therefore, could have been more disappointing than to discover that the brain of the chimpanzee,

as far as structure goes, presents us with not only every lobe, but with every convolution of the human brain.

The chief facts, indeed, respecting the functions of the different areas of our own brain cortex, so far determined by physiologists, have been deduced from experiments on the brains of anthropoid apes. All attempts to demonstrate a new, or superadded, or special collection or arrangement of gray matter in man's brain, which no other animal possesses, have failed. Ever since Huxley showed, against Owen, that the human brain has not even one peculiarity not found in a baboon's brain, no one expects that the scalpel will reveal a single physical explanation as to why the mind of a baboon and the mind of a physiologist who dissects him are so infinitely apart. If the similarity of brain formation and mechanism, carried out to the smallest details, be all that is needed, there would be no reason why baboons could not become philosophers or mathematicians.

Man's body, therefore, including his brain, leaves man himself wholly unexplained. Professor Huxley puts the subject thus: "As to the convolutions, the brains of the apes exhibit every stage of progress, from the almost smooth brain of the marmoset to the orang and chimpanzee, which fall but little below man. And it is most remarkable that as soon as all the principal sulci [fissures] appear, the pattern according to which they are arranged is identical with that of the corresponding sulci of man. . . . So far as cerebral structure goes, therefore, it is clear that man differs less from the chimpanzee and orang, than these do even from the monkeys, and that the difference between the brain of the chimpanzee and of man is almost insignificant when compared with that between the chimpanzee brain and that of a lemur."

But there is one physiological standard by which man can be truly measured, which applies to him alone, and which rounds his

whole marvelous being — his faculty of speech. The immeasurable distance between man and every other animal on earth is fully accounted for by the existence, the nature and the significance of man's *words.* By the sayings of Francis Bacon we find ourselves in the presence of an intellect which grasps the principles of all knowledge. In the words of Shakespeare wellnigh every experience of human life is vividly embodied. We are awed by the sublimity and the solemnity of the thoughts of him who expressed himself in the words of the Ninetieth Psalm. So, the more we ponder it, the more impassable grows the gulf between the minds of those who could speak thus and the minds of dumb animals. They cannot be the same beings in kind, however similar their bodily relationships be, because the more we recognize what the presence of the Logos in man implies, the plainer becomes the reason why he stands alone in this world.

Professor Huxley remarks on this sub-

ject:[1] "After passion and prejudice have died away the same result will attend the teachings of the naturalist respecting that great Alps and Andes of the living world—Man. Our reverence for the nobility of manhood will not be lessened by the knowledge that Man is in substance and in structure one with the brutes, for he alone possesses the marvellous endowment of intelligible and rational speech. . . . Thus he stands as on a mountain top, far above the level of his humble fellows, and transfigured from his lower nature, by reflecting here and there a ray from the infinite source of truth."

Regarded as a physiological study the faculty of speech consists not in uttering words, but in the power of word making. The primary truth about a word is that it comes only from mind. Apart from mind it has no existence. Every word was originally made by a personality which first designed and invented it. No personality, no making of a

[1] Man's Place in Nature, pp. 119, 132.

word is forever true. Hence no word ever came, or can come, into existence spontaneously. No human being was ever born with a word. A word, therefore, is an artificial human product, the outgrowth of a need, just as a knife was first made by some one who wanted to cut. Being purely human creations, words, like all man's works, sooner or later grow old and die. Some of the finest languages ever spoken are now dead. Therefore it is not words as such which concern the physiologist, but the capacity for making them, for this is the faculty of speech itself.

This faculty has all the characters of a fundamental physiological fact, because it is absolutely generic. No speechless race of man has yet been found, however low we go in the scale of human intelligence, or however isolated the race; and every speech of savage tribes consists, like every other speech, not of so many sounds, but of verbs, nouns, and partitives, that is, with all of

the distinctively mental elements of true language.

Not the least impressive fact about this exclusively human faculty is its limitless power of creation. The remarkable excellence of the languages of many savage races is a testimony to the innate power of this human endowment. Thus the Turks were originally a barbarous horde of High Asia. Their language was wholly formed while they were so. It is one of the finest, if not the finest, sounding languages in the world. It has been the least modified by foreign influences or admixture of any language in Europe. It has never had any literature of its own worth mentioning, but this is what Max Müller says of it:[1] "We have before us in the Turkish a language of perfectly transparent structure, and a grammar, the inner workings of which we can study as if watching the building of cells in a beehive. An eminent Orientalist remarked, that we

[1] Science of Language, First Series, p. 309.

might imagine Turkish to be the result of the deliberations of some famous society of learned men. But no such society could have devised what the mind of man produced left to itself in the steppes of Tartary and guided only by its innate laws, or by an intuitive power as wonderful as any within the realm of Nature."

Mr. Crisp, in a paper read at the Anthropological Section of the British Association of Science, August, 1905, said:[1] "The Bantu languages of Africa will express any idea, however esoteric, and will do it with extraordinary precision and often with great felicity. A foreigner who has acquired one of them will often leave his own language to use a Bantu word, because it conveys his thought more aptly and tersely. Bantu proverbs and metaphors are often most incisive, emphasizing with much power and delicacy what it is intended to say. They are masters in the art of destructive criticism, and their native

[1] Nature, Nov. 16, 1905, p. 66.

shrewdness, observation and wit render them dangerous disputants."

In the infancy of philology some theorists ascribed the beginning of words to phonetic imitations of natural sounds. But this bow-wow theory, as it has been called, soon died after the recognition of the infinite human capacity for making languages. As natural sounds are the same the world over, if this view were correct, some similarity in sound should be found in all languages among the words so derived, which is by no means the case. Even in baby talk, where most we would expect to find them, the words vary in sound between the different races as much as do the words of adults. Thus the word "bow-wow," meaning a dog, is found only in English. Indeed, one might as well trace a navigable river to a bottle of water, as to suppose that the inexhaustible stream of human speech has any other source than the limitless spirit of man, for, owing to that fact, human speech is far richer than any one language

possibly can be. There is much truth in the saying that a man doubles himself when he learns a new language. Whoever enters upon the study of one of the great languages of the East, such as the Arabic, soon notes not only how unlike any European tongue it is, but that it teems with words and constructions and meanings which have no equivalents in any Western speech.

The necessary conclusion, therefore, which the philologist must come to from all these facts, is that the source of all words is the conscious mind or human personality itself. It is not, as some reasoners loosely state, that language makes man, but it is man who makes language. The mind comes first and is altogether the beginning and cause of the word. We need to emphasize this primary truth lest it escape us when we find that all words have their material anatomical seats in the brain upon which we can put our index finger. Otherwise we might infer that these material localities, these speech areas of gray

matter, do themselves originate the words which are located there. We shall find instead that the material seats of words in the brain matter no more make those words than the shelves of a library make the books arranged on them. The ultimate fact is rather, as revealed by the physiological study of the faculty of speech, that words are the instruments which the thinker invents or makes for himself for the purpose of defining his thought. Their relations to thought are just as definitely instrumental as the violinist's fingers are instrumental to the expression of his thoughts and feelings with the violin. The violinist thinks first in time before a finger moves, and the thinker thinks first in time before a word rises to his lips. By degrees, however, the mind becomes so habituated to think only by using its word instruments that in adult life thought without words becomes almost, if not quite, impossible, because in all thinking, as such, the man talks to himself in words, whether he will

later talk to others or whether he be thinking alone. If any one doubt this, let him try to represent a true thought to his consciousness without its accompanying words.

It should be clearly recognized that this applies only to thought and not to feelings. Thoughts need words to become true thoughts, but feelings do not need words to become true feelings; in fact we often vainly try to express our feelings in words, and find words fail us. We must again disclaim here any excursion into the field of metaphysics, for as we proceed with our discussion, we will meet with illustrations of what will happen to an adult's power of pure thinking upon actual material damage to his brain word apparatus. When such damage is complete, though manifestations of feeling may remain, all recognizable signs of thought are gone.

Having considered the relations of words to thoughts, we now come to a crucial point in all our discussion, namely, the relations of

words to the brain. We can scarcely overstate the importance of certain modern discoveries on this subject, because they reveal the first recognizable link between the immaterial and the material, between mind and matter, yet demonstrated in science. That link never would have been guessed by metaphysicians, for it was only physicians who could have discovered such facts by their noting the effects of small and strictly localized brain injuries. The simplest way to illustrate this statement is to narrate some experience of physicians which teach these lessons of such extreme interest.

I was once hurriedly sent for by an old patient of mine. I found her much disturbed by a strange experience which she immediately detailed in the well-chosen words of an educated woman. "What is the reason, Doctor," she said, "that everything in a book or newspaper is illegible to me? Last evening I sent an advertisement to the *Herald* for a waitress, and when the girls came this morn-

ing I could not read their references. I then took up the *Herald* and found that I could not read a word in it. At first I supposed my eyesight had failed, but I could see everything around the room as well as ever, and so also with my crochet work. I then opened the Bible, but could not read a word. What *is* the matter with me?" I at once recognized that she had been struck with word-blindness, as this affection is technically termed, and from that day to her death, two years later, she never saw a word. In a moment of time she had become as illiterate as an Australian savage, and she remained so. Having calmed her excitement as best I could, I was able to note that she had absolutely no other disorder of speech and none of vision. She heard every word that came to her ears, and she could speak as fluently as ever, but no word could reach her consciousness through her eyes. All that which as yet had happened to her was that a little artery which supplies blood to a small area in the visual region of

her brain had become plugged, with the result of totally disorganizing the gray matter where eye words are registered. The words, "the blood thereof, which is the life thereof," find their best illustration in that most living of things, the brain gray matter, for it immediately dies if deprived of its supply of blood.

Another example of the total loss of the power of recognizing words occurred in a hospital patient, but in him it was not words that came through the eye, but words that came through the ear, which he could not recognize, so that he had what is termed word-deafness. He was a naturally intelligent young man under thirty, a clerk in a mercantile establishment, and was supposed to have become insane, because though he talked incessantly, he talked only gibberish, and moreover he did not seem able to understand what was said to him. It was soon found, however, that he could read and write as well as ever, so that to all questions that

were put to him in writing he wrote correct answers. The reason why he talked so incoherently was because he could not hear his own words, and for the same reason all words addressed to his ears reached his consciousness only as sounds, but were otherwise as unintelligible to him as the words of a language which he had never heard. It was also words only that he could not hear, for he heard and recognized all other sounds, including the tick of a watch and the notes of a canary bird. Such cases of word-deafness are due to the same kind of damage to a small locality in the auditory area of the brain as that which causes word-blindness in the visual area.

A third form of loss of words is still more common. A man retires to bed in good health, but is found in the morning utterly unable to speak a word. It is soon ascertained that he has no word-deafness, for he evidently understands everything that is spoken to him, and that he has no word-

blindness, because he can read. But he may not be able to utter a word, still less a sentence. In his distress, he may make signs that he would like to write, but even if he can hold a pen well and begin to write, it is usually found that he cannot find the words to express himself by writing any more than he can by speaking.

Thus it is that processes of disease enable us to analyze our brain mechanism of speech with all the precision of well-devised experiments. By this means we learn, as otherwise we could not, that speech is of two kinds. The first kind consists of words which come *to* us, and these are words which arrive through the ear, and then go to a particular locality in what is called the first temporal convolution, which is in the cortical area of hearing, where they are received as words; and the second consists of words which come to us through the eye in reading, and which go to an entirely different place from the ear words, for they are received as words in a

special locality called the angular gyrus in the cortical visual area. It is to be remembered that there is no resemblance whatever between the sound of the word man, for example, and the written word man, for sound and sight are two wholly separate things; and hence sound words and sight words have each their different brain registries. Modern invention has doubtless added a third word registry connected with the sense of touch, by which the blind are enabled to read, but its special locality has not yet been identified.

The second kind of speech consists of words which go *from* us, or which we ourselves utter. This division of the faculty of speech is wholly different from the first, because in that we are passive and *receive* the words, while in this we are active and ourselves *give forth* the words. We do this either by word of mouth or by word of hand in writing, and to thus express ourselves an entirely distinct mechanism is required, because it involves

muscular movements. It is therefore called motor speech, and proceeds from an altogether different place in the brain cortex, in a region from which muscular movements are initiated, particularly in those regions which govern the movements of the tongue and other muscles of articulation, and which are also in proximity to the motor areas governing the hands. Here in a small patch of gray matter, not larger than a hazel nut,[1] located in a part of a convolution called Broca's convolution, from the French surgeon who first identified its connection with speech, resides every word that can be spoken! Let this remarkable piece of matter be separately destroyed, as it often is by a gush of blood from a ruptured artery, and the consciousness is utterly unable to find a word with which to express itself. It still may have its power to receive all words from others through the ear or eye, but not a word can it communicate

Rosenstein, quoted by Sir Wm. Gowers: Diseases of the Nervous System, vol. ii., p. 115, 2d Edition, 1901.

in return. These different derangements of speech, due to organic changes in the word mechanism, are technically called *aphasias,* and divided into the sensory forms, when eye or ear words are deranged, or motor aphasia, when Broca's convolution is damaged.

Now, as we have remarked before, the gray matter of no one of these three seats of words originates or makes any words. They are simply registered there for use, as they would be on a printed page, or on a wax leaf of a phonograph, and how that is done we will learn further on.

We have already likened those speech areas to the shelves of a library, with words arranged thereon like so many volumes, and that something very similar to this is actually the case, is demonstrated by facts such as these. When a man sets about to learn a language new to him, he has to add another brain shelf for that purpose, because the old shelf has too many books on it to allow any room for a row of entirely new words. Pro-

fessor Hinshelwood,[1] of the University of Glasgow, publishes the case of a highly educated man who was brought to him for an attack of ordinary word-blindness. He could read his native English in print only with the greatest difficulty, and words in writing scarcely at all. As Dr. Hinshelwood was told that the patient had learned Greek, Latin and French, he first tested him with Greek, when the patient was surprised and delighted to find that he could read Greek perfectly, as he did paragraphs in Homer, Thucydides and Xenophon. Then testing his Latin, he could read it far better than he could English, but not as perfectly as Greek, while in French he made more mistakes than in Latin, but still read it a great deal better than he could his native English. The only explanation, of course, of this case is that the injury to his brain matter nearly ruined the English shelf, then damaged to a less extent the French, and

[1] Lancet, Feb. 8, 1902. Also his book, Letter, Word and Mind Blindness, London, 1901.

still less the Latin shelf, while the Greek shelf escaped entirely.

The same arrangement holds true also in the auditory word mechanism. Dr. Hinshelwood reports the case of a Frenchman who made his living in Glasgow as a teacher of French for a number of years, during which he learned English. After returning to his native country he had a stroke of apoplexy, from which he became word-deaf in French, while his English shelf remained intact so that his wife could speak to him, but only in English.

These cerebral library shelves may also be partially, instead of completely, damaged by accidents to the brain, with results not unlike those which often disturb the equanimity of a student when the house-cleaning season arrives, and women invade his study for a general dusting of his books. For days afterwards he picks up the wrong book, because it has been put back where it does not belong. So, after some brain shock, a person may be

able to speak, but the wrong word often vexatiously comes to his lips, just as if his Broca shelves had become badly jumbled. To this condition the term *paraphasia* is given.

There may be shelves in these cerebral libraries, however, for other things than words. Professor Edgren of Stockholm has published the records of a number of patients who had lost the power of reading music, though they could still read words, that is, they became music note-blind instead of word-blind. In Dr. Hinshelwood's patient mentioned above, who could read Greek but not English, the reverse took place, for he could still read music as well as ever, though he could not read a sentence in English.

The most interesting, however, of these separate registries is that for figures. As the damage to the speech apparatus often involves more than one registry, the following record of a case in my own experience is of interest, because it proves that if only one of the three speech mechanisms remain un-

injured, the personality can use that one sufficiently well for all practical purposes. A gentleman who during a long, active business career had accumulated a fortune, had an attack of apoplexy which, while causing no muscular paralysis, yet made him both word-blind and wholly unable to utter a word. He remained in this condition for seven years, but what brought him to my office, in company with his lawyer and only son, was that my opinion was sought as to his competence to make a will. His lawyer produced one in which the patient devised a certain amount of property, consisting of pieces of real estate and of other items, each very definitely mentioned, to his married daughter, which was, in the testator's opinion, a very fair division of his property between his two children. His manufacturing business, however, he devised exclusively to his son. Learning that his son-in-law was dissatisfied with this arrangement, and might induce his wife to contest her father's will after his death by a

claim to a share in the profits of the factory, on the ground that in his condition he was incapable of making a will, he came to me as an expert to give my written opinion on the subject. It was naturally felt by his son and his lawyer that a very plausible case might be made out to the jury by the other side, that a man who could not himself read a word of his will, nor utter a sound by which he could express what he wanted, might easily be imposed upon by the persons interested to do so. In my examination of him it was found that though he could not read, and likewise could not write, as his utterance speech mechanism was wholly ruined, yet he could both read and write figures as well as ever, in fact that he was unusually adept in all arithmetical calculations. Meantime nothing could persuade him to retire from business, and so for seven years he continued to buy and sell as he always had done, for he wrote the sums for all transactions and pointing to the figures with his pencil, the bargain had

to be forthwith concluded. In illustration he produced a memorandum book of his, in which were entered numerous such accounts, particularly directing my attention by his finger to one of them in which he had bought a third interest in a business enterprise, and in which he had entered all payments correctly on that basis, the sums varying according to the year's profits. As questions relating to the testamentary capacity of aphasics have come up in many courts of both Europe and America, quite a literature has grown up on this subject, and I proceeded to test this particular case according to its accepted rules. I took the will and looked it carefully over before him, and then read it aloud, item by item, to each of which he nodded assent, until I designedly misread one stipulation as in favor of the son when it was actually in favor of the daughter. The old gentleman was furious at my supposed mistake, and was quick to correct any other inaccuracies in my reading, however minor in importance they

were. I therefore could give a decided opinion that he was entirely competent to devise a will, and I was glad to learn afterwards that this precautionary measure on his part prevented any trouble in settling the estate when he died some months afterwards. The place for registering figures is doubtless somewhere in the visual area of the cortex, but in his case so removed from the eye-word registry that it escaped damage as completely as his ear-word mechanism had done.

Meantime this patient had repeatedly tried to learn to speak and to read again after the sudden onset of his calamity, but though he endeavored with characteristic perseverance to get back some of the lost parts of his speech, yet he failed altogether. Mentally he was just the same, and his personality with all its peculiarities remained the same, but those particular chords of the instrument were irretrievably broken. Why he could not substitute another set of precisely similar

chords which he had in his brain, and which also were perfectly intact, we will explain in the next chapter, because that explanation covers the whole subject of how we talk at all.

CHAPTER VI

THE FACULTY OF SPEECH—CONTINUED

It should be noted first of all that no part of the human brain has any original, that is, native connection with the gift of speech. The material seat or region in the brain of this great faculty comes always as an acquired change in the brain, for no one ever was born with it. Hence at birth speech has no place or locality whatever in either hemisphere. We may even go so far as to say that if the distinguishing fact about man is that he is a speaking animal, this is not owing to the structure of his brain, for not only has the chimpanzee just the same convolutions which man has for speech, but like the chimpanzee, man has the same convolutions in pairs, that is, in both hemispheres. And yet man uses only one of these pairs for speech,

while the same set of convolutions in his other hemisphere is no more used for speech than either pair is used for that purpose by the chimpanzee. If, therefore, the word faculty was an original endowment of those word areas in man, on account of their particular construction, those areas being just alike in each hemisphere, then both hemispheres would be used for speech. Instead of this being the case, the entire word mechanism in all its parts is found only in one of the two hemispheres, while the other hemisphere remains wordless for life.

With the great majority of persons the speech centers are located exclusively in the left hemisphere. It is a part of the left superior temporal convolution which hears words; it is a part of the left angular gyrus which sees words; and it is the left Broca's convolution which utters words. In all such persons the corresponding places in the right hemisphere are not speech areas at all.

It would be natural to infer from all this

that the left brain is organized differently from the right brain as far as this supreme endowment is concerned. But it is not so, for the good reason that in some persons the speech centers are in the right brain alone, and it is their left brains which are the wordless ones. Moreover such persons are not a whit inferior to the others in everything which language demands.

Therefore, again, it is not brain structure, nor organization, nor locality, nor brain cells or fibers, nor any similar thing which is the first cause of word making. That first cause is something wholly different, namely, an agency, or rather agent, which visits these brain localities, and finding them originally entirely unfamiliar with a single word of any kind, proceeds by a long and incessant repetition process of teaching, to fashion those particles of gray matter to do what he proposes, here to receive words and there to utter words. How he manages to do this is revealed by his original reason for choosing

the left brain in most persons, but in others not the left but the right brain.

The facts which led to the discovery of the first steps in the formation of the word mechanism in man were that it was noted that when sudden paralysis occurs on one side of the body, if it be the right side which is paralyzed, the side which is governed by the left brain motor or uttering speech is also very commonly affected. The reason for this is that Broca's convolution, which contains the center for motor speech, as we have already explained, is situated in that part of the cortex which is called the motor area, because from that area proceed those excitations of muscular movements which are of a voluntary kind. A powerful spurt of blood from a ruptured cerebral artery may so tear the brain tissue as to involve these motor centers or the fibers leading from them, and in so doing frequently involves Broca's convolution among the rest. Post-mortem examinations fully confirm this statement.

Meantime as the right hemisphere is then found to be quite unaffected, including the right Broca's convolution, it is plain that the loss of speech is due exclusively to the injury to the left hemisphere.

On the other hand, while loss of speech ordinarily accompanies right-sided, but not left-sided paralysis, some cases have been reported in which it accompanied left-sided, and not right-sided paralysis. In time more of these cases were published, along with the significant post-mortem findings of damage to the right instead of the left Broca's convolution. In other instances, in patients who, with left-sided paralysis and loss of motor speech, had also showed word-blindness during life, not only the right Broca's convolution, but the region of the right angular gyrus was likewise found damaged. As the corresponding places in the left hemisphere were intact, it followed that in these persons the speech centers were in the right brain and not in the left.

It was not long before this seemingly curious anomaly found its explanation, which is that right-sided paralysis with loss of speech occurs in right-handed people, and left-sided paralysis with loss of speech occurs in persons who have been left-handed in life. In other words, the faculty of speech is located in the hemisphere which governs the hand which is most used. Hand and speech, therefore, are physiologically connected.

This remarkable fact brings us back to the origin, to the very beginning of this wonderful faculty of expression in man. It began by one personality longing to communicate with others, and the first thing which he did then, as every human being still does when endeavoring to communicate with those whose vocal speech he does not know, was to make gestures with his hands. Gesture language, therefore, was the first language, and few persons are aware how much gesture language still continues in living use. This is particularly noticeable among all peoples

who have no written language; but even among the most civilized, whole races are characterized by the number and variety of their gestures while speaking, quite as much as by their vocabulary. A non-gesticulating Frenchman is as uncommon as a taciturn Frenchman. One has to learn two languages among the Arabs, for nothing can exceed the expressiveness and piquancy of those gestures by which they often more than double the meaning of their words.

The important place which gesture language holds among primitive peoples is well illustrated by the following anecdote: Dr. Walter Roth, in the preface to his Ethnological Studies of the Northwestern Queensland (Australia) Aborigines, says: "I was out on horseback with some blacks, when one of the boys riding by my side suddenly asked me to halt, as a mate of his in front was after some emus, consisting of a hen bird and her young progeny. As there had been apparently to me no communication whatsoever

between the boy in front and the one close to me, separated as they were by a distance of quite one hundred and fifty yards, I naturally concluded that my informant was uttering a falsehood, and told him so in pretty plain terms, with the result, that after certain mutual recriminations, he explained, on his hands, how he had received his information, the statement to be shortly afterwards confirmed by the arrival of the lad himself with the dead bird and some of the young in question. . . . I afterwards found that there is an actual well-defined sign language which extends through the entire Northwestern districts of Queensland."

Among our staid Anglo-Saxons a preacher like Whitfield moved his audience more by what they saw him do with the muscles of his face and of his hands than by the words he uttered, for those words we have in his printed sermons, and we wonder at the effect they had on his hearers. His voice certainly could not account for the whole difference.

An inspection of the accompanying plate shows in what close proximity to the area governing the movements of the hand in the motor region of the brain are the centers which preside over the movements of the muscles of the face, of the lips and of the tongue. A common and associated action of these parts, therefore, would be much more natural than between the muscles of the face, for example, and those of the leg. We can then see how readily facial expression, lending itself to gesture in attempts at communication, would seek the co-operation of lips and tongue for vocal sounds, soon to become words because of the human mind back of the sounds. This last element of mind, as we will note later, is indispensable, because otherwise the sounds would have remained forever only like those of an anthropoid ape.

But as the right hand is the oftenest used for every purpose, so is it of the two hands the oftenest used for gesture, which means of course for language. As soon as other

parts were sought for to co-operate with gesture in language, the appeal would necessarily be to the neighboring centers in the left brain, and not by crossing the corpus callosum bridge to the corresponding centers in the other hemisphere. It would not be long, therefore, before the habit became settled to use only parts in the left brain for this specialized work, until finally the habit became fixed for life.

Why some people are left-handed we do not know. The discussion on the origin of right-handedness and left-handedness comes down to us from ancient times and is ever renewed. Scarcely a month passes without it being all threshed out again in our medical journals. But the primary connection of the hand with the fashioning of the word mechanism in the human brain is conclusively settled by the location of that mechanism in the right hemisphere in left-handed persons. Whence, therefore, the impulses mostly proceed for using the particular hand in ques-

tion settles both to what cerebral places words are to go, and from what place they are to come.

So far we have been led by anatomical facts. Thus, Broca's convolution is no more a theory than a finger is, for it is a definite material thing. But what makes Broca's convolution talk? Evidently not simply because it is Broca's convolution, because there is another Broca's convolution within the same cranium which does not talk.

This question, which really concerns the origin of human speech, is not best answered by studying speech in children and noting how they begin. Many reasoners go astray here, because with preconceived views about the automatic origin of words, which children are supposed to learn by imitation, they wholly ignore the anatomical brain changes which are necessary to make speech, and what it is which causes them. If they are studied it will then appear that these anatomical changes cannot possibly be of automatic

origin, but rather must be the effects and results of purpose. The best age, therefore, for starting this investigation is when the subject begins to learn to read.

The ability to read constitutes an important department of language, and no human race has yet been found which cannot be taught to read if the attempt be made early enough in life. Thus Bishop Hale, of Perth, W. A. (in his Aborigines of Australia), mentions that " A shepherd, Adams, has taken to wife a native woman, who had been brought up at some settler's station and was partially educated. Adams could not read, and the black wife taught the white husband to read."

It is no longer doubtful that *every* race of man can be educated to know anything, from reading and writing to mathematics, philosophy and political economy. In other words man is always and everywhere man, and infinitely distant in mind from every ape. Some early anthropologists were mistaken enough

to say that certain races of men were too low in the scale to be able to count above five, the number of their fingers, and they cited some tribes among the Australian savages as examples. We need only quote the following as to the actual facts.

Mr. James Dawson, in his Australian Aborigines, published in Melbourne in 1881, records the following remarkable evidence: "The inspection of the aboriginal school at Ramahyuck, in Gippsland, during the past eleven years, gets a percentage of results higher than the other state (white) schools in Victoria, and while no doubt this excellence is largely due to the regularity with which the children attend school, and to the skill and zeal of the gentlemen who teach them, it fairly shows that aboriginal children are at least equal to others in power of learning those branches of education which are taught in the state schools of Victoria. On several occasions of examination by a government inspector, the percentage of the

Ramahyuck school was a hundred, a result unparalleled by any other school in the colony.''[1]

Now no one can imagine that learning to read can be automatic. It requires instead the most persevering attention and application for many months. Over and over again the pictures of the separate letter have to be identified so as to be distinguished from one another, and then their combination into words successively mastered till the word symbol and its meaning are simultaneously recognized. This process of brain shaping has to be done piece by piece, or layer by layer, so that some persons become word-blind without being letter-blind. But a less spontaneous cerebral act than this can scarcely be conceived. If it is not wholly the doing of what we call *will*, then what *is* it? But the most pregnant fact about this pro-

[1] See article, The Position of the Australian Aborigines in the Scale of Human Intelligence, by the Hon. J. Mildred Creed, in the Nineteenth Century Magazine, January, 1905.

cess of learning to read is that by the constant repetition of the will-directed effort to see the letter and word pictures, an actual modification of gray matter results in a limited portion of the visual area, so that it can do what no other gray matter anywhere can do,—see and recognize words.

Here, surely, we come upon a most impressive fact, namely, that by constant repetition of a given stimulus, we can effect a permanent anatomical change in our brain stuff, which will add a specific and remarkable cerebral function to that place, which it never had before, and which, therefore, it could not have had either originally or spontaneously. This material change must be there, though no microscope will ever detect it, or identify the English reading from the French reading cells, in one who can read both languages, but yet there it must be, or a blood clot could not destroy it. But this material change was not effected easily; rather it came only by laborious and long con-

tinued work spent on that collection of gray matter, and work by something which must be wholly extraneous to the gray matter itself. It is absurd to suppose that any other areas of the cortex which cannot of themselves recognize a letter or word, are the teachers of the cells in the angular gyrus which do the reading. It is the conscious personality alone which does this work, and no better proof of this is needed to show that such must be the process than when, in later years, a student learns to read Greek, Latin and French, as did Dr. Hinshelwood's patient above cited. When that man separately studied those three languages, in addition to his childhood's speech, his consciousness and his will certainly co-operated in prolonged exercise, until wholly distinct portions of his gray matter were fashioned, one for Greek, another for Latin, and another for French words, each so divided from each other and from the earlier English stratum, that they were respectively differently

affected by the damage which involved this word area.

We must here pause in our discussion, because we have come to a great principle which goes to the foundation of everything nervous, from the nervous system of a polyp up to the brain of a philosopher. That principle is this: That a stimulus to nervous matter effects a change in that matter by calling forth a reaction in it. This change may be exceedingly slight after the first stimulus, but each repetition of the stimulus increases the change, with its following specific reaction, until by constant repetition a permanent alteration in the nervous matter stimulated occurs, which produces a fixed habitual way of working in it. In other words, the nervous matter acquires a special way of working, that is, of function, by habit. We will find this principle constantly illustrated and operative in many ways as we proceed; but what concerns us now is that already, from the facts which we have been review-

ing, we arrive at one of the most important of all conclusions, namely, that the gray layer of our brains is actually plastic and capable of being fashioned. It need not be left with only the slender equipment of functions which Nature gives it at birth. Instead, it can be fashioned artificially, that is, by education, so that it may acquire very many new functions or capacities which never come by birth nor by inheritance, but which can be stamped upon it as so many physical alterations in its proplasmic substance. All this is demonstrated beyond cavil, by the textural brain changes which the acquired and not congenital function of speech depends upon.

This well-demonstrated truth is of far-reaching significance, because it gives an entirely new aspect to the momentous subject of Education. Most persons conceive of education vaguely as only mental, a training of the mind as such, with small thought that it involves physical changes in the brain itself ere it can become real and permanent. But

we have seen that different forms of education, as perfect examples of education as can be named, are ultimately dependent upon the sound condition of certain portions of the gray matter which have been "educated" for each work. Thus to read music requires a great deal of education, and an apoplectic clot may instantly deprive a person of a laboriously gained power to read music, or such an accident may spoil every other kind of reading, and yet leave the music-reading place unharmed. What a burden of school days arithmetic was every one remembers, but in those same days figures were deeply engraved in some part of the angular gyrus, so that, as in the case mentioned on page 99, when all other reading cells were ruined, they remained as clear as ever for their owner's use. Or, again, they may be spoiled while the reading of music notes remains. So writing, which heretofore has been regarded as a form of Broca's convolution work, because usually when this convolution is damaged

speech by mouth and speech by hand are both abolished, very probably has a center of its own, since cases are reported where the individual could not speak but could write. Some investigators claim to have identified the writing center in a part of the motor area above Broca's convolution.[1]

From all this it follows that the brain must be modified by every process of true special education. A skilled violinist can play upon his instrument as easily as another can read a book. But how did he acquire such an accomplishment? Without doubt by actually fashioning a special violin center in his brain, as reading cells are fashioned, by the same laborious iteration of exercise of those particular brain cells, until they had to become violin music cells. And so with every handicraft. Instances which prove this have been reported of mechanics, who after an apoplectic attack, have had their right hand sud-

[1] Prof. C. K. Mills, Am. Jour. Med. Sciences, September, 1904.

denly but permanently lose its cunning, while but little else or nothing seemed to be lost.

Meantime one fact about the plasticity of the matter of the human brain cortex, in other words, its educability, is that this plasticity diminishes progressively with age. This is much more evident with certain brain functions than with others, but is particularly the case with the acquisition of language. Children under ten years of age acquire languages by the ear very easily; that is, the gray matter of their word centers is very plastic and can soon be fashioned for that purpose. But what is gained easily is lost easily, for if a child at that age be removed to another country, where he no longer hears the language which he has learned, he generally forgets it totally in less than two years. On the other hand, many cases are reported of children becoming aphasic just as adults do, by the onset of right-sided paralysis with destruction of the left Broca's convolution, and yet they gradu-

ally learn to talk again in much the same fashion in which they acquired speech at first. That they do this by educating the centers in the right brain is proved by parallel cases of the supervention afterwards of total aphasia, when left-sided paralysis was added to their former right-sided paralysis, *i. e.,* by a second injury involving the right centers.

Facts of this kind have led some writers to draw the erroneous conclusion that both hemispheres are concerned in speech, so that if the word centers of one side are injured, those of the other hemisphere can come to the patient's help. The chief argument for their position is the transitory character of loss of speech in certain persons affected with aphasia. In a few weeks they recover their ability to read or speak as the case may be, and it is therefore argued that they do so by help from the centers in the unaffected hemisphere. But it does not seem to occur to these reasoners that, if so, then every case of aphasia from injury in one hemisphere

should soon be recovered from by the aid of the other hemisphere. But the facts are that in the great majority of cases in adults, if the aphasia does not improve within a few months, certainly within a year, it never improves. My shrewd patient who retained his arithmetic so well took many a lesson for six years with all the assiduity of an industrious schoolboy, and yet he never got back a word in his left angular gyrus, nor in his left Broca's convolution, nor of course in the right word centers. The most probable explanation of temporary aphasia and recovery or improvement from it is, that the sudden injury causes a shock, and thus paralysis of the word centers, but not complete disorganization of them, so that in time they regain their functions, rather than that the structures in the other hemisphere—which had not for years been taught a word of English any more than of Chinese—should in a few weeks be able to read or speak. The older the patient is, the more hopeless the case, simply

because the unaffected word areas in the other hemisphere have passed the time of life when the gray matter is plastic enough to be fashioned for any new complex function. A healthy man after forty scarcely ever learns a new language well; after fifty such instances are of the rarest; and at seventy the best that can be expected is the mastery of a very few foreign phrases, and badly pronounced at that. We need not dwell further on this subject, for it is simply in keeping with the facts connected with any other mental acquirement which comes only by education. A physician needs many years to get his education, and who would expect him at fifty or sixty to become a civil engineer?

Our study of the cerebral relations of the faculty of speech serves one purpose at least, namely, that of revealing the great fact that man can be educated and does educate himself by modifying his brain for that purpose. It is this fact which makes man what he is—man. But for the purpose of our discussion,

it is so important to be able to recognize clearly how our brain matter can be made to acquire wholly new functions, and according to what fundamental principles of nervous physiology it does so, that we must for the present diverge from the subject of education to that of the great laws governing all nervous development. Above everything else modern science is indebted to the recognition of the principle of evolution as the chief guide to the understanding of the deeper problems of life. By this is meant that all life development, and certainly all nervous development, has been *orderly;* which, in turn, means that from the beginning, however low, to the end, however high, certain fundamental laws continuously operate. We, therefore, can best unravel the most complex forms by studying the commencement in the simplest forms; well assured that if we never drop the line of continuity it will be our clue through the most intricate passages of our search. We will

then find that as we approach the subject of the brain of man in its relation to thought by another route entirely than that which we have been following, namely, by the route which leads from below upwards, we will arrive all the more certainly at the conclusions to which we have been so far tending, with all the added confirmation given by the convergence of independent lines of research. We proceed, therefore, in the next chapter to the consideration of the great laws which preside over the evolution of a nervous system.

CHAPTER VII

EVOLUTION OF A NERVOUS SYSTEM

Certain fundamental principles are always found underlying the essential phenomena of life, which, first recognizable in the most primitive, prove afterwards to be just as operative in the most developed forms. The greatest growths, for example, in either the vegetable or animal kingdoms, a towering oak or an immense whale, have to begin like every other living thing as veritable microbes in a single microscopic cell. The inner structure of that cell itself has certain invariable elements which are equally present in the first vegetable and in the first animal cell. Thus every species of plant or animal contains in its first cell a fixed, specific, and always even number of bodies called chromosomes, because they can take a dye, and this number

regularly recurs in all the subsequent cells of the future body, though they be millions. Thus in the cells of the mouse, the salamander, the trout and the lily, the chromosomes always number twenty-four. In the ox, the guinea pig, in man and in the onion, the chromosomes always number sixteen. In the shark the number is thirty-six; in the grasshopper twelve, and so on. It is from such facts, and others like them, that the eminent naturalist, Von Naegeli, was led to say that all life is one.

But nowhere is the steady sway of fundamental principles so illustrated as in the development of a nervous system. From the first beginnings of a nervous system in a polyp up to the marvelous brain of man, certain primary laws are always operative, without their ever being afterwards repealed or superseded. If, therefore, we are to understand the complex, we first must study the simplest organization, well assured that what is illustrated by it will continue recognizable

in every further development, however great or manifold.

In studying the development of a nervous system from a physiological point of view, the first principle discernible as governing that development is what in any other connection we would term Discipline, and we cannot do better than to note how the conceptions suggested by that word are applicable to our subject.

One of the definitions given in Webster of the word "discipline" is "subjection to rule, submission to order and control, by severe systematic training." The central idea conveyed by this definition is that discipline in no way represses activity, but directs it, by means of regulated restraint. Without activity there could be no discipline, for there would be nothing then to discipline. The word, therefore, implies some kind of energy, made to subserve some purpose which it would not effect unless it be put under control.

But in its usual and most correct sense, discipline is not a word which can be applied to any inanimate force. It is an exclusively nervous system word. You cannot properly say that you will discipline your watch if it goes too fast, though you can say that you will regulate it. Nor can you properly say that you have disciplined the energy of steam, when you have made it subserve your purpose by putting it under control in an engine. It must always be something nervous that is disciplined, so that even in the bodies of the highest animals, nothing but that which is nervous can be either disciplined or trained.

This may seem a singular statement to some, as they think of the highly trained muscles of the legs of a dancer or the fingers of a pianist. But it is not the muscles in these cases, but the motor nerves of the muscles, which have been so wonderfully disciplined. For neither of these instances of supposed muscle training can be compared for com-

plexity and difficulty with the training of the muscular organ, the tongue, for the movements necessary for articulate speech. An animated orator has to make a greater number of rapidly succeeding and yet perfectly adjusted contractions and relaxations of his muscles of articulation, than any famous performer on a musical instrument. But how shall we explain the authenticated case of a man who could speak English, French and German, and who suddenly became unable, from an attack of right hemiplegia, or paralysis on the right side of his body, to make his tongue work out a word in any one of the three languages?

What was the matter with his tongue? Nothing, as a muscle or muscular organ. In fact it could work as well as ever in assisting mastication and swallowing. Why, therefore, could it not talk? Solely because its nervous direction for the movements in speaking was lost, while its nervous direction for the movements of mastication was re-

tained. But if its pair of hypoglossal nerves were also cut, just as the accident which had caused his hemiplegia had severed the connection with the higher brain centers, then the tongue would have failed equally to assist in mastication and in deglutition. It is a mistake, therefore, to say that muscles, as such, can be taught to do anything. Nothing can be taught except that which is nervous.

This principle is far-reaching, because among other things it introduces us to a second element of fundamental importance and which is characteristic of the nervous system alone, namely, that of gradation of rank in work or function. Every tissue of the body, except the nervous tissue, has but one dead level of function. No one bone or bone cell has any higher rank than another bone or bone cell, any more than one brick in a building is of a higher or more important grade than another brick, simply because it is put above or below. And so muscles are little else than duplicates of each other in function,

because, wherever they are, they will be found to do but one thing, namely, contract and relax, and nothing more. There is, therefore, no such thing in the muscles as one set governing another set by virtue of pure innate superiority, as the rider is superior to his horse. The horse might claim against his rider the greater importance, because he does all the going, and so he might if he were like his rider, and not a broken-in horse. But just this difference meets us in the case of the gray motor cells of the spinal cord and the gray motor cells of the surface of the brain. The gray motor cells of the cord do all the going of the body, for even the so-called cranial motor nerves really belong to its system. Not a muscle of the body is directly under the control of those aristocratic motor cells in the topmost layer of the brain. The cord might say to the brain, "If you wish to move hand or foot you have to ask me to do it for you." "Very well, then, do it," is the brain's answer, "but don't you

move hand or foot till I tell you, for since I have been evoluted up here, you have lost your senseless independence and must obey me. You were the original nervous system, to be sure, just as there were horses before there were men to ride them, but since I have come, I am above and you are below, and, as it is, it took me long patient training and a great deal of trouble to break you in to my service, so that you would act according to my orders."

Rank, however, always implies an ultimate below, from which everything starts as a common foundation for all subsequent gradations, and so we will begin now with the simplest illustration of what a nervous system is. Reduced to its most primitive form, as it is in the lowest animals which show a trace of a nervous system, it is proved to consist of three parts: (1) A nerve filament which receives and transmits a stimulus to (2) a nerve center of soft gray cells and fibers, which receive this stimulus, and which

center reacts to this stimulus, never on the nerve which brought it, but on (3) a nerve filament which proceeds from the center.

Hence these two filaments are accordingly named, the first *Afferent,* because it transmits to, and the second *Efferent,* because it transmits from, the center some nervous vibration. One of the commonest examples of efferent excitation is when muscles contract in response to the efferent excitation of their motor nerves. A fair illustration of this mechanism can be found in ourselves in the act of winking. You can abolish the power to wink in one of three ways. You may do it, first, by cutting the branch of the fifth cranial nerve, which transmits sensation to the nerve center for winking at the top of the spinal cord. This center then does not know that any winking ought to be done, because it depends for all news of that kind on the sensory fifth nerve, and that has been cut. Or you may abolish winking by cutting the proper branch of the seventh pair of cranial

nerves; then, no matter how the fifth nerve tells the center that it ought to wink hard, the center answers, "I cannot do it, because the seventh nerve, which is the efferent or motor nerve that works the muscles of the eyelids, is cut." Or lastly, with both the fifth and seventh nerves intact, no winking will occur because the nerve center itself has been deadened by some narcotic poison.

From that simple beginning of a real nervous system, one can proceed, step by step, with animals still utterly brainless, but which have more developed and complicated nervous systems; and yet in them no other mode of working than by afferent, centric and efferent elements can be discovered. What one finds in these more organized nervous systems is a greater number of these centers, each with its afferent and efferent nerves, but with one important addition, namely, that the separate nerve centers in them are connected by short nerve fibers, which are for the purpose of enabling the centers to work

together, something as the jars of a Leyden battery are connected by short chains.

A still further development shows a regular chain of such nerve centers forming a distinctly ascending series, whose functions never change or abolish the original afferent and efferent mode of working, but instead show a more and more perfect harmony of action between the several parts. By this harmony of action new results in movement, or in the direction of movement, are secured, which would be impracticable were the separate centers to work independently.

After a certain number of nerve centers have become associated, according to the scale of the animal's development, we find that the mutual co-operation of the centers begins to be plainly more frequent in certain directions than in others; that is, that it seems easier for the centers to act together to execute some movements than to execute other movements. When we examine why this is so, it proves to be because of the more

frequent repetition of certain afferent stimuli than of the other afferent stimuli. Repeat one afferent excitation a hundred times and another only once, and the movements consequent on the first are clearly much more readily caused than those following on the unusual excitation.

Therefore we have come now to the second and most important principle of all, in the organization of a nervous system, and which we have alluded to in the previous chapter, namely, Habit. The whole nervous system indeed in any animal, man included, is first organized by habit. However complex, for example, be the movements executed by muscles in order to produce a given effect, *e. g.*, the movements of the eyeballs, some muscles contracting strongly, others most gently, others again relaxing just enough to allow their opponents to contract just so much and no more,—all these perfectly associated movements are nevertheless explicable only as the slowly acquired habits of the centers

which supply those muscles with their motor nerves. Hence the important question, how did these centers come to acquire these habits? The answer is, from a thousand thousand times repeated afferent impressions along the optic, or sense of sight nerve, in habituating the efferent or motor nerves of the eye muscles to act together.

Physiologists, therefore, when they speak of nerve centers being organized to perform such and such functions, mean, not that the nerve centers have been created so from the beginning, but that habit has so organized them.

But the important principle to bear in mind here is that it is the afferent segment of the nervous system, or that which is acted upon by stimuli from the outside world, which is the ultimate source of this great fashioner of the nervous system, Habit, and not the nerve center itself, nor the efferent segment. This principle well nigh overshadows all others in its bearing upon the question of the origin

and development of a nervous mechanism. We will gain no insight into the deeper problems of nervous organization if we relax our hold on the continuous presence and operation of afferent excitation all the way from the swaying arms of a Hydra Fusca up to the successive trains of thought in a human brain. We thus speak of it now, because further on we will have to refer repeatedly to the place of the Afferent in discussing some subjects, second to none in importance, about our own mental operations. Here, however, we start with the fact that it is the Afferent only which connects with the Environment. Upon the Afferent the nerve center wholly depends, not only for the primary source of its activity, but for the organization of that activity so that it can ever become uniform. The reaction of a nerve center to an afferent stimulus has been likened to an explosion of energy set free by the lighted fuse of the Afferent. But that explosion would be an explosion and nothing more, but for that one great fact

about the afferent nerve itself, namely, that it always causes the explosion to be in one direction only. Over and over again it does exactly the same thing as at first, and thus trains the nerve center to react only in one fashion.

All this is due to the great law that an afferent nerve never varies in what it does. As Professor Sherrington expresses it, the afferent nerve,[1] "extending from the receptive surface to the central nervous organ, forms the sole avenue which impulses generated at its receptive point can use. It constitutes a private path exclusive to the impulses generated at its own receptive points, and other receptive points than its own cannot receive it." The nerve centers, therefore, become accustomed to react in the same way to afferent stimuli, because these stimuli are never mixed or confused with others.

[1] Presidential Address, Section of Physiology, Brit. Assoc. Science, 1904.

It is quite otherwise with either a single efferent nerve, or with any organized nervous path for efferent impulses, for these may be used in response to a great variety of afferent stimuli. Thus the act of coughing is executed by a whole group of motor nerves acting together in a regular way. But this same efferent path for coughing may be used by a number of very different afferent stimuli starting from the nose, pharynx, larynx, bronchi, pleura, stomach, brain or other organs, so that not uncommonly it requires some search to find what the particular cause of the cough is. It may be a bean in a child's ear, or a worm in the intestine. An afferent stimulus, on the other hand, never breaks its rule of using none but its own path of excitation, and hence it is the source of sources of this great factor, Habit, in nervous evolution.

Another peculiarity of afferent excitation, to which we shall have to allude again in the very highest connection, namely, in the succession of ideas in human thinking, is that

an afferent stimulus, though always itself single, once it excites an efferent act in a nerve center, may have that excitation spread from center to center, as it were, like so many successive efferent explosions. Thus a sneeze is always due to the excitation of a minute twig in the sensory or afferent nerve of the nostril, which then transmits it to an efferent center in the medulla oblongata at the top of the spinal cord. This efferent center then sends this excitation to fifty-five pairs of efferent centers to cause them to call their one hundred and ten muscles into one combined and well-regulated sneeze performance.[1]

[1] A number of writers on nervous disorders seem to regard an attack of epilepsy as due to a spontaneous discharge of nervous energy in some cortical brain centers, the motor area being especially involved when the attack is accompanied by convulsions. As no other examples of spontaneous efferent actions can be cited, but on the contrary, such always follow upon a preceding afferent stimulus, I would ascribe the true beginning of an epileptic paroxysm, whatever its form, to an abnormal afferent excitation. This view of the nature of this serious nervous disease has an important bearing upon its treatment, as I explain in an article on the Pathology and Treatment of Epilepsy in the N. Y. Med. Journal, Nov. 8 and 15, 1902.

All that we have said heretofore finds a complete illustration in the structure and functions of the spinal cord in all vertebrates. The spinal cord, which is the original nervous system in every vertebrate, as it is the first to appear in its embryonic development, consists of a great number of nerve centers, one above the other, all receiving their afferent and giving off their efferent nerves on each side, and as constantly joined together by tracts of communicating fibers, until finally the whole muscular system of the body is found to be under its exclusive control. As remarked before, no primary law or function in the nervous system is ever superseded by any later developments; and so, however great be the additions afterwards of brain centers or functions, yet the spinal nerve centers retain all their original prerogatives, quite as much in man as in any of the rest of the animal world. If, as remarked above, you wish to show the cunning of your right hand in any work of skill, or the fluency

of your speech with your tongue, your designing and talking brain has to ask the spinal nerve centers for the muscles of the hand and for those of the tongue to direct those muscles to do the work for it.

Meanwhile this wonderfully organizing power of afferent habit works out results in creating special functions or modes of working in the spinal cord which actually startle us with their close resemblance to what we are accustomed to regard as manifestations of design or purpose. Thus if a vigorous frog be suddenly decapitated with a sharp knife, and his headless body be put on a plate, it will forthwith jump up and assume on the plate a perfectly natural, if not somewhat impertinent attitude. If now a small drop of acetic acid is applied on the frog's side, as soon as it begins to irritate the skin, the headless frog gravely and deliberately raises his hind leg and brings up his foot to scratch off the acid. If more acid be applied, he brings down the arm to help scratch the same

spot; and if the irritation continues, he begins to lose balance by trying to bring up the other leg also; until at last, as if the itching had become intolerable, he makes a most natural dive for the floor.

An amusing illustration of this kind once occurred to me in my college days, while fishing in a western stream with a classmate. My companion's luck had been poor, when at a deep, promising pool he became greatly excited by a powerful bite, with a pull which bent his pole nearly double, only to find at last that he was drawing up a great mud turtle which had swallowed the hook beyond mistake. In vain my friend tried to persuade the turtle when he landed him to put his head out from under his shell till he could get the hook free. Finally, as he had no other hook, my friend hung the turtle over a branch and sawed his head off with his jack-knife. Down at last dropped the turtle's headless body, when to our astonishment it straightway walked some two yards

right into the water and dove off into the deep pool, just as if the creature kept an extra head under its shell to put on in an emergency!

In animals below the vertebrates, the nervous system being composed of fewer series of centers, and all acting alike to their afferent stimuli, they proceed with such uniform and rigid habits of action that, like other examples of unmitigated consistency, it occasionally leads to inconvenient results. While sojourning in Syria I was told that the whole country round Mt. Lebanon was dismayed one year by the news that a vast army of marching locusts was coming from the eastern desert. The governor of the district ordered a regiment of soldiers to aid the people to construct a great rampart of heath bushes to be set on fire as the locusts came up to it, hoping thus to save the gardens of Beyrout. These locusts always hopped straight ahead, and on coming to a house went up its stone walls, over it and down it,

as if it were a level place, and in such inconceivable numbers that an American resident described the noise of the great host passing over the roof as like to that of a tremendous hailstorm. At every green leaf on the way each took a bite, and then went on for the next one to take his bite, until in an incredibly short time not a green thing could be seen. When they reached the prepared heaps of heath and these were set on fire, the locusts marched on without pausing, until in a brief time they put the bonfires completely out. As the sea was not far off everybody hoped that they would take to surf bathing. And so they did. Just as certain injurious political crowds among us can always be depended upon to march up to the polls and vote the straight ticket, when the vanguard reached the waves, like all good true locusts, in they hopped, followed by all the rest, till the billows seemed to roll only grasshoppers; nor did the scene end until the last of the rear guard, faithful to the

great law of Afferent, Centric and Efferent, had skipped over the heaps of his dead comrades to make his last jump into the blue waters of the Mediterranean.

In structure the spinal cord has its centers located within, and like all ganglionic matter they are of a gray color. There is a special arrangement, however, of its cells according as they subserve an afferent or efferent function, the afferent cells, of a more or less rounded shape, being grouped more toward the posterior segment of the cord where the afferent nerves enter, and the cells with efferent functions, usually larger and of a stellate shape, being grouped toward the anterior segment whence the motor nerves emerge. At the top of the spinal cord, as it enters the skull, is developed the final supreme center of the entire system—the Medulla Oblongata—that fit and most responsible ruler of the whole wonderful and beautifully regulated spinal mechanism,—that center in which a small injury would

threaten life more than it would in the brain, as it may cause instant death, for the medulla holds the reins of the pulse and of the breath in its hands, while at the same time it acts as the intermediary between the various regions of the brain above and those of the spinal cord beneath.

But the chief feature about this remarkable nervous apparatus, the spinal cord, is that however intricate its adjustments be, so that by it the most complicated and combined movements are executed, enough as we have seen to wear all the aspects of designed or purposive muscular acts, yet from first to last its operations are purely automatic. This is because its workings are all organized by the steady, unvarying operation of afferent stimulus. Without that there would be no centric change, and without centric change there would be no efferent impulse. Originally nothing could be more haphazard than afferent stimuli, and thus at first the centric change would be correspondingly so; but

when the same afferent stimulus recurs over and over again, the centric change becomes fixed by this repetition, and the efferent impulse follows suit, till a special mode of working, or, in other words, a special nerve function is established. A watch or a clock, therefore, could not be a more automatic mechanism than is a spinal nerve center.

The desirability of distinctly recognizing the part taken by afferent habit in the organization of nervous functions leads me, at the risk of being tedious, to cite another illustration of the kind. The nervous mechanism of the act of breathing is a primary example of such organization. The afferent stimulus in the form of the sensation of the want of air, coming up by the afferent vagus nerve, leads to the successive efferent muscular movements of inspiration, and then of expiration, with all the regularity of the swing of a pendulum. Now let the habit of checking the return swing of the pendulum during expiration be contracted, especially in childhood,

the habit-forming age, by prolonged coughing, as in whooping cough or in measles, and there is danger of this bad habit in breathing lasting for years, or for life, in the form of the wretched disease, asthma. It should be noted that the act of coughing always occurs in expiration, thus interrupting the regular rhythm of expiration quickly following inspiration. In asthma, the air enters easily in inspiration, but is checked in expiration, so that this latter, instead of being equal to inspiration, as in health, may in asthma be five times as long. Once the normal habits of breathing become deranged, the respiratory center may be at the mercy of a great variety of afferent stimuli, which are never perceived in health. Thus one form of asthma is called "cat asthma," because the mere entrance of a cat into the room will start the patient wheezing, though wholly ignorant that the animal is near. The son of a medical acquaintance of mine knew immediately by his breathing that some buckwheat was in the

house, though he was in his own room on the top floor, and it was found that the cook had surreptitiously brought the forbidden article into the kitchen and was mixing it with water to make cakes for herself. I have had more than one patient who could sleep well in New York, but who would be sure to be awakened by an attack of asthma if they spent a night in Brooklyn across the East River. Other asthmatics have their attacks induced by the most trivial derangements of digestion, and but few of them can safely eat a hearty meal at night. Such whimsicalities of this complaint might be multiplied indefinitely, only to illustrate that there is always risk in interfering with old normal nervous habits. The constant coughing of chronic bronchitis will frequently induce its form of asthma in adults; which, however, generally subsides if the bronchitis be cured.

But it is in the medulla that we meet with special illustrations of a third great law of nervous development. To return for a

moment to our first principle of discipline. That principle, whether applied in armies or in anything else, implies some source or sources of authoritative restraint, generally a regular hierarchy of commanders, one ranking the other. Nowhere in any instance is this great principle of discipline so impressively demonstrated as in the army, so to call them, of active centers in the nervous systems of the higher animals. A constantly recurring word in books on nervous physiology is "Inhibition," as descriptive of the workings of certain nerves or nerve centers.

One example will illustrate what this word refers to. By stimulating with an electric current one nerve which comes down from the medulla to the heart, you make the latter beat more powerfully and rapidly. By stimulating another nerve which also descends from the medulla to the heart, that organ at once begins to beat more slowly; stimulate that nerve still further and the heart beats very slowly; still more again and it comes to a full

stop. Now cut that same nerve and the heart bounds off to the most rapid, tumultuous beating. As an eminent physiologist characterizes it: This nerve bridles the heart, for when it is severed the heart behaves like a horse who throws its rider and straightway takes to racing. For this nerve is the inhibitory or governing nerve of the heart, that nerve which makes the heart a strong heart by governing it. If you suddenly tell a man a dreadful piece of news, and his pulse scarcely quickens or quivers, is he a weak man or has he a weak heart? Another man sees a street boy preparing to snowball him, and at once his pulse runs up to 120. What is the difference between these two men? The difference lies in the cardiac branches of their vagi nerves.

Now as we investigate the functions of this great law of inhibition in the nervous system, we find that as higher centers are developed in the series, their influence is shown not only in new powers or functions super-

added to the older ones, but that they constantly inhibit, or, in other words, control the action of the lower centers. Thus in the frog a mass of centers called the optic lobes are developed just above the medulla. Now as long as these lobes are connected with the spinal cord, you may stimulate the afferent spinal nerves of the frog, and but little or no reflex movement will result. Cut, however, the connecting tract, and thus free the cord from the control of these higher centers, and the slightest tickling of the skin will then make the frog kick actively.

After we pass the medulla oblongata, we find ourselves proceeding along large tracts of nerve fibers which soon present us with a series of considerable swellings along their course, and which are found to be altogether new or differently constructed masses of gray matter, or ganglia as they are called. These new ganglia prove to be chiefly portentous developments of the afferent system, causing in fact the afferent segment to take the

lead in nervous life, for they are no less than the centers of the special senses of sight, smell and hearing, larger or smaller according to the needs of the animal for each sense respectively.

Now when we use the term special senses, we mean a form of sensation. But what is sensation itself? Nobody knows. All definitions of sensation amount to saying that sensation is sensation, for to call it an act of the consciousness is, when translated into Anglo-Saxon, to announce that the thing which feels, feels. This Something called Consciousness makes its first appearance in vertebrates after the whole mechanism of the spinal cord and medulla has been completed, and the lower vertebrates seem to need but little else for their world than these special sense ganglia, which are proportionately developed in them according to their life habits. However even in them two other swellings appear, which are relatively wonderfully small in many of these animals considering

their great import, as they are no less than the beginnings of the cerebral hemispheres, or what we call the brain in ourselves.

The accompanying figures tell the story of their evolution. In Figure 1 we have the

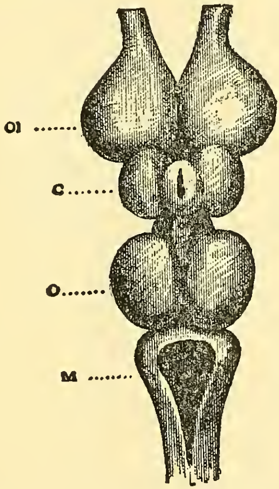

FIG. 1—The Brain of a Lamprey.

sensory ganglia and the brain of a lamprey, a small fish often mistaken for an eel from his form. Those rounded masses 01, represent his olfactory lobes, for his habits require him to be good at smelling. Then the

two large swellings below are his optic lobes, while those two insignificant spheres between, marked C, are his cerebral lobes or

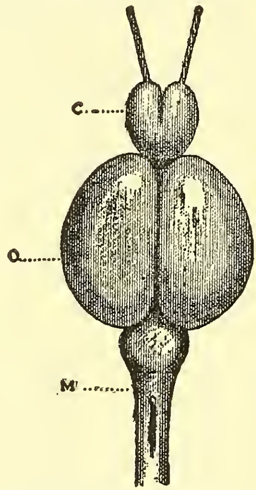

Fig. 2—Brain of a Carp.

brains, or all that he has to cogitate with. Fig. 2 shows the sensory and intellectual apparatus of a carp. He does not smell at all, so he has no olfactory lobes, but his optic lobes are large compared with his brain or mental equipment. Fig. 3 represents the apparatus of that old friend of the physiolo-

gist, the poor frog, in which his mechanism for thinking, though larger than that of fishes, is scarcely larger than his optic lobes.

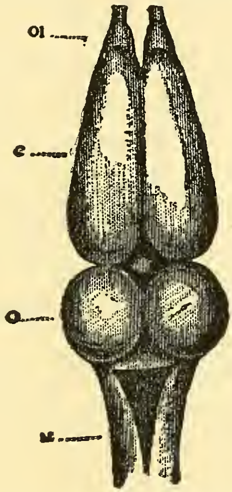

FIG. 3—Brain of a Frog.

M, in each of these figures represents the medulla.

In some fishes, such as the carp, when the ganglia which correspond to the cerebral hemispheres are experimentally removed, they do not seem to mind it at all, for even then there is little, if anything, to distinguish

them from perfectly normal animals. They maintain their natural attitude, and use their tails and fins in swimming with the same vigor and precision as before. They not only see but are able to find their food. If worms are thrown into the water where they are swimming, they immediately pounce upon them. If a piece of string similar in size to a worm is thrown in, they are able to detect the difference, and they drop it after having seized it. They even, to some extent, distinguish colors, for when some red and some white wafers are thrown into the water, the fish almost invariably select the red in preference to the white.

It is much the same with the frog. If care be taken to keep the frogs alive after the removal of their cerebral lobes until they have quite recovered from the injury, brainless frogs will behave just like full-brained frogs under like circumstances. They will crawl under stones, or bury themselves in the earth at the beginning of winter, and after the

period of hibernation is over, they will come out and diligently catch the flies which are buzzing about in the vessels in which they are kept.

But Fig. 4, which shows the brain of a

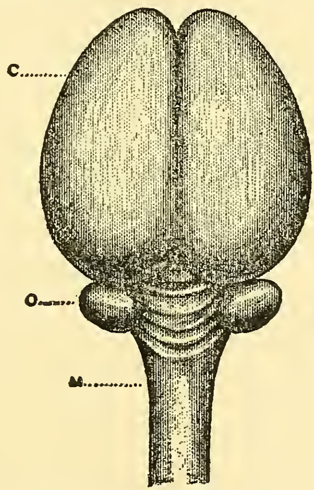

FIG. 4—Brain of a Pigeon.

pigeon, illustrates how much higher in the scale birds are than fishes and amphibia. The original basal ganglia which we have been considering, are beginning now to be completely overshadowed by the cerebral

lobes, and hence after their removal, birds show much greater alterations in their behavior. Memory and volition seem annihilated, and the birds do not seek their food. But if the optic lobes are uninjured, the bird will walk round the room, avoiding obstacles; it will fly from one place and alight securely on another, always preferring a perch to the floor; and if placed on a swinging cord, it balances itself perfectly with the to and fro movements. If placed in a special attitude, it ruffles its feathers and shows fight, thus illustrating that pugnacity antedates brains, or, as physiologists express it, belongs to a lower level.

In the ascent from birds to mammals, the development of the cerebral ganglia or lobes grows from mere bulbous swellings into great masses which cover more and more the sensory ganglia, until in the monkey these are wholly buried under their mass. In man these original centers at the base of the skull are relatively so insignificant, that we are

accustomed to leave them out of consideration, and to speak of his cerebral hemispheres as his brain.

As regards the functions of the brain and their relations, the first conclusion we come to is that an unmistakable promotion, so to speak, has occurred in the mammalian brain of the great functions of sensation, consciousness and the power of directing movement, from the basal ganglia of fishes, amphibia and birds up to the great cerebral ganglia above. Remove these from a mammal, and it is then far from acting as if it still had the same degree of consciousness or power of movement left which those lower in the scale possess.

This does not prove that the cerebral ganglia have entirely superseded the original basal ganglia, for facts of disease at the base of the brain in man show that even in him, these original nerve centers still hold much of their old relations. The case instead is like the history of a prosperous firm which

began business in a very small way and in humble quarters, and then when it had branched out to an undreamed of extent from its lowly start, the highly trained heads of the company are found to have moved up to large and commodious apartments on the upper floors, while the original routine work is yet done, as of old, in the stories below. Simple, routine work is quite enough now for the basal ganglia, while consciousness is needed to go up higher where the far wider operations of mind have to be carried on. Nevertheless it is the same old firm, for we will find that its principles and modes of doing business by the heads of the establishment have not changed, though they are now handling millions where they used only to deal with a few dollars.

We may not unnaturally think that in ourselves, the far range of our memories, imaginations, feelings and ideas must have a very different genesis and be according to very different laws from the simple unconscious

functions of the first example of a nervous system which we have described. But a little attention to the source and sequence of our ideas, even when taking their widest sweep, will show a quite unmistakable correspondence to the old original methods of nervous work.

Thus even with that unique mental faculty of speech, which we have been considering at length, we are met at the outset with our old familiar terms Afferent and Efferent, as plainly as in any function of the spinal cord. Our speech consists of words which come to us through the afferent channels of the ear and of the eye, and of words which go from us by the efferent Broca convolution. Moreover, in the order of time, the afferent preceded and created the efferent, for the child first heard the words addressed to its ear, and then slowly taught Broca's convolution to respond; slowly, for it evidently understands words some time before it can learn to stammer them on its tongue.

But likewise many of the longest and most intricate workings of our minds in acts of thinking, can often be traced to a single afferent excitation which was the origin of the whole process. One familiar illustration will suffice. While you are in your reclining chair, perhaps with your eyes shut, some friend casually plays on the piano in the adjoining room an old well-known tune, which you were fond of in your father's house years gone by. A throng of memories of long ago, of faces not seen for years, of some that will never be seen here again, pictures of places and scenes, with their events and experiences, all crowd upon you till you are startled by tears welling up in your eyes. You spring up at finding yourself so deeply moved by—what? By that single afferent impression coming through the auditory nerve!

In fact any analysis of our ordinary mental processes, made by retracing step by step how one idea has been suggested by a

previous idea, and that in turn by another, will usually bring us at last to some one afferent excitation coming to us from our outside world. That is just the old way in which the Afferent works, as we showed, on page 146, how in the spinal mechanism it executes a sneeze. We need not be metaphysicians to make this discovery, that our thinking so often begins first with some sensation then experienced. Nor does it take long to find that many of our trains of thought, as they are well termed, are somehow habitual to us, as if we have fallen into the way of thinking thus. In other words, our old friend, Habit, whom we have seen to be such a multiform organizer of spinal ganglia and spinal functions, seems to have organized our brains also! He has thousands of private afferent wires with which to reach our consciousness from every part of our bodies, each one of which can start a sensation, and that an idea, until it seems difficult to deny that our thoughts are but the products of

this great afferent creator of nervous operations.

Some may infer from these considerations that we have come to the end, that is, that we need not go further in explaining the "how" of our thinking selves. Many, indeed, have thought so, and have maintained that we men and women are mentally the results of our environment, that is, of our outside world creating us by its afferent excitations. The nervous system of a polyp is certainly a pure mechanism, a most mechanical affair, but the principles of its mechanism continue just the same through every step in the long series of Evolution, till at last we find those virtually mechanical principles accounting for—Man!

But in our next chapter we will find ourselves face to face with an entirely new fashioner of nervous matter, one to whom brain protoplasm is as clay to the potter.

CHAPTER VIII

THE BRAIN AND PERSONALITY

In the preceding chapter we have seen that the evolution of a nervous system is guided by a great principle, which on the last analysis may be regarded as a specific nervous reaction to environment. By means of the undeviating inflow along the afferent channels of stimuli from the outer world or environment, the receptive nerve elements are affected till they in turn excite an outflow along the efferent channel; and when the same afferent stimulus is repeated often enough, the consequent efferent effect becomes so uniform as to constitute a special mode of nervous action, or, in other words, a nervous function. It is thus that this afferent agency coming from without continuously proceeds, fashioning one system of

nervous centers after another, until at last it begins to look as if out of the human brain itself, it constructs what is virtually a pure thinking machine like all its previous mechanisms, and whose operations, though more complex, yet illustrate the same automatic principles which govern the functions of the medulla oblongata. This inference seems legitimate, because in so many of its activities the human brain appears fully to exemplify just the same order of reactions which we have met before at lower levels.

Why is this not enough? It is in no sense enough, simply because the brain of man and the mind of man do not correspond. There is a gap here which no facts of animal evolution account for. Man's brain in physical and anatomical respects corresponds quite closely to that of the chimpanzee, and hence, according to all precedents, his mind should show but little advance in degree, and none in kind, over the mind of this ape. We cannot allow at this point any confusion in

reasoning to obscure this fundamental fact. On the one side is Homo, properly placed in zoölogy among the Primates, because in his body as in his brain he clearly belongs to that class of animals.

But it is thus as to his mind. Those stupendous works, the bridge across the Firth of Forth and the Simplon tunnel through the Alps, existed down to the smallest detail in their engineers' minds before they existed on earth. It is by his mind that a man is enabled with a glass prism to calculate to a mile the distance between two fixed stars, which not the greatest telescope can show as other than one star. By his mind another draws the map of a country as it was in the Silurian period. By his mind a third is excited to enthusiasm over the[1] interesting deduction of the equations for the infinitesimal motion of a rigid body from the invariance of the expression $dx^2 + dy^2 + d2^2$. So such illustrations, multiplied to infinity, of

[1] Prof. Sylvester; Works, vol. i., p. 34.

human mental activity in science, philosophy, religion, poetry, art, statesmanship, finance and the rest, lead to the single conclusion that while the gap between the brain of an anthropoid ape and the brain of man is too insignificant to count, their difference as beings corresponds to the distance of the earth from the nearest fixed star.

Therefore the brain of man does not account for Man. What does? We are bound by our premises to seek for an answer to this question only by searching the brain itself, to note whether in it there are evidences of the presence of something whose agency affords the sole explanation why the human brain differs so in its capacities from any other animal brain. That something, which would account for everything, is, we claim, the Ego or the Human Personality.

This statement of ours brings us to the great issue which sharply draws the lines between the partisans of two opposing doctrines. On the one side the contention is that

there is no such thing as personality apart from the brain. The organization of cerebral matter accounts for everything mental and moral in man. The conception of the human personality as an entity independent of, or separate from the material organ of the mind they pronounce to be as unreal as the conception of " vital spirits " of former times. To speak of the soul is pure mysticism and should be rejected as unscientific. Our consciousness instead represents only a passing phase of our cerebral activities, and the Ego in us is nothing more than the functional result of the arrangement for the time being of the molecules or ions of our brain matter.

On the other side, personality is affirmed to be the most certain reality of the universe. All other phenomena are contingent upon, and relative to personal consciousness. As to the Ego, the statements of the other side are to be rejected because they are purely metaphysical assumptions which are wholly con-

tradicted by the physical and material facts which show that brain matter has itself no properties of mind, and becomes related to mental processes only in certain localities by becoming there artificially, and not originally nor congenitally endowed with such functions. It is not with his whole brain that a man knows, thinks or devises, but he does so in limited areas of one hemisphere thereof, which he himself has educated for the purpose. The question then follows, how came these brain places to be thus chosen and not others precisely like them in original organization? That this great creative choice proceeds from no source in the brain itself is demonstrated by the following considerations.

Thus, as we have already shown, the speech centers in the brain are as much the creations of the individual himself to store the words in them for clothing his thoughts withal as if he made a wardrobe in which to store garments for clothing his body. The

speech centers no more generate the words in the one case than the wardrobe manufactures the articles which it contains. Hence men supply themselves with as many different languages as they invent different costumes, though no one ever started in life with either of these equipments. In fact he might inherit clothes but never words, for word centers in the brain must always be personally made, because no brain of itself ever made a word.

As we stated in Chapter VI, this is proved beyond mistake by the human faculty of learning to read, which rules out the error of some theorists, who, confining themselves to observing how little children first learn speech through the ear, ascribe the faculty to automatic imitation. But a reading center in the angular gyrus has nothing to do with the ear, and moreover it can be made only at the age when purposive prolonged intention takes the place of echo-like imitation.

But we are now about to enumerate a most important series of facts, which like those previously mentioned, came to light by medical experience, and which go even further than the discovery of the speech centers in demonstrating how the brain is physically related to thought. We begin as before with an actual occurrence—this time in surgery.

Sir William MacEwen, the eminent Professor of Surgery of the University of Glasgow, gives the particulars of the case of a mechanic who received a severe injury to his head.[1] Immediately after the accident he was in a peculiar mental condition. Physically he could see, but what he saw conveyed no impression to his mind. Thus an object presented itself before him which he could not make out, but when this object emitted sounds of the human voice, he at once recognized it to be a man who was one of his

[1] Sir William MacEwen; Address before the British Medical Association on the Surgery of the Brain and Spinal Cord, Brit. Med. Jour., 1888, vol. ii., p. 307.

fellow-workers. He was equally unable to recognize his wife and children. By eyesight he could not tell how many fingers he held up when he placed his own hand before his face till he became cognizant of the number by the sense of touch. These symptoms gave the key to the hidden lesion in his brain and therefore where to trephine his skull. On operation it was found that a portion of the inner table of the skull had been detached from the outer and had become imbedded in the gray matter of that locality. The bone was removed from the brain and reimplanted in proper position, upon which he recovered and returned to his work.

It is evident from this that that fragment of bone interfered with an important mental function located in just that brain spot which it penetrated, because so soon as it was removed from that place the mental function returned. What was that mental function? It was not sight, for the man saw his wife and friends as well as before, but he did not

know what he saw. Hence, seeing and knowing what is seen are not the same thing, because each of these mental processes has its separate seat in the brain. But as knowing appears to be so much higher as an intellectual performance than the simple sensation of sight, writers have inaccurately termed this special form of abolition of intelligence mind-blindness, to distinguish it from word-blindness, which follows upon damage to the word center in the angular gyrus. But word-blindness which renders a person wholly illiterate, because he no longer recognizes printed or written words when he sees them, though he knew them perfectly before, is as much an example of mind-blindness as was this patient's mind-blindness, the only difference between the two being in the things which were seen. In word-blindness words are seen but not known; in this so-called mind-blindness objects are seen but not known. In both, therefore, the blindness is the same in nature, namely, mental blindness.

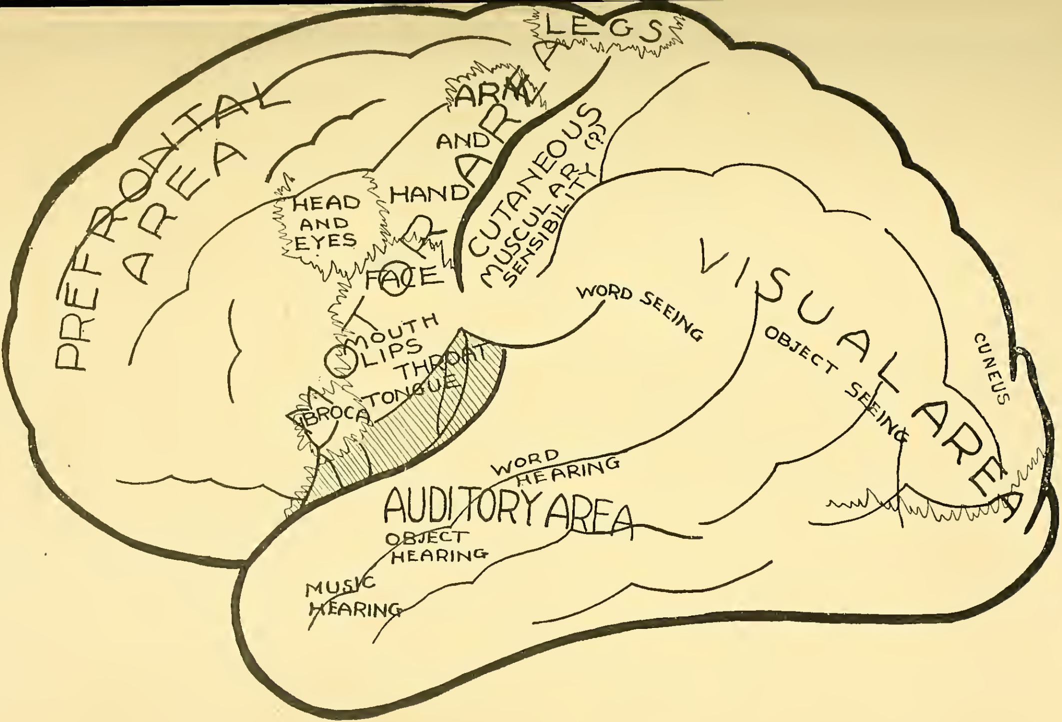

PLATE I.
DIAGRAM OF THE FUNCTIONAL AREAS ON THE SURFACE OF THE LEFT HEMISPHERE IN A RIGHT-HANDED PERSON

As this inability to recognize visual objects has been frequently observed after localized damage to the brain from disease, the locality itself where things perceived by sight are then known has become as well identified as is the word center in the angular gyrus, with the same important deductions about the way by which this mental function comes to be so localized as in the case of the eye word center. That is to say, we learn to know how we know what it is we see by first discovering where this act of knowing is done, and secondly, by establishing the fact that no other place in the whole brain save this knows anything by sight, and also why this is so.

In explanation we shall first state that the primary center of sight in the occipital lobe is in the neighborhood of a wedge-shaped convolution called the cuneus. (See Plate I.) This convolution, of course, is found equally in both hemispheres, and that it is directly related to sight is proved by the fact

that it is only when the region of this convolution is destroyed in both hemispheres that total blindness is produced. That function of sight in the cuneus is doubtless congenital, but the child when born does not know what it sees. That particular power is afterwards acquired, not by the cuneus, but by an adjacent area of brain cells, in front of the cuneus, which we ourselves for the purpose of convenience will hereafter call the precuneus.[1] How this locality comes to acquire this important mind function of knowing what visual objects are, we will discuss after those equally interesting and still more varied facts connected with the recognition of sounds.

Thus in the temporal lobe is found the original center of hearing, just as the cuneus in the occipital lobe is the original center of sight. But a whole group of centers becomes developed afterwards around the original

[1] Some writers attach this term to a different portion of the sight object area.

auditory center, each one of which has learned what different kinds of sound mean. One of the greatest of these is that for music, and a divine faculty it is, because more than anything else it is the speech of the soul as it awakens to a communion with the great harmonies of the non-material universe. A true musician must have a richly furnished shrine for the goddess of Music in his temporal lobe, and that he has is proved by some persons, who, after having been very fond of music, and able to tell at once whether they were listening to a composition by Mendelssohn, or one by Wagner, suddenly experience the sad misfortune technically termed *amusia.* No longer can they recognize any tune, however familiar, and in vain they try a violin or piano to bring back to them their departed joy. They *know* no music thereafter, the reason being that material damage has happened to the center in the temporal lobe which has been separately educated for music, just as another place in the

same lobe has been separately educated for words.

We have already described what is meant by word-deafness, as well as how it is caused. But besides the center for words and the center for music, the auditory area of the temporal lobe has a place where the meaning of sounds in general is recognized, as the visual area just mentioned has its place for recognizing objects of sight. Let this auditory area be separately damaged, and the unfortunate then cannot tell the sound of a locomotive whistle from that of a church bell. All sounds, including the voices of his friends, are alike indistinguishable noises to him. To this condition the term mind-deafness has been given, signifying sound-meaning deafness.

Therefore while the ability to know is a great attribute of the human mind, yet these facts prove that there are actual physical bases in the brain on whose integrity as such this faculty can alone be exercised. An

artist may be lost in admiration while gazing at the Sistine Madonna. An apoplectic clot may make him the next day, though still able to see that great picture, no longer able to distinguish it from a wall paper. A trained musician may be entranced at one time listening to a symphony of Beethoven, but in a few hours, though still able to hear it, he may be wholly unable to recognize it as music. In both cases a highly developed mental capacity is lost immediately after a local brain injury. How are we to explain this sudden abolition of superior mental endowments by such physical changes?

The explanation is as conclusive as it is important, namely, that these knowing areas are found in the same brain hemisphere that contains the speech centers, and in that hemisphere only, so that the inference is certain that they are all created by the same agency. Thus Professor MacEwen's patient was a right-handed man, and the splinter was driven into a convolution of his left brain,

that is, into the speaking and not into the wordless hemisphere. Now, he had just the same collection of cells in the corresponding region in front of the right cuneus, and moreover they were not injured at all in the accident; nevertheless they could not help him recognize his wife and children any more than those cells could read Latin! It is evident, therefore, that those right hemisphere cells, though they could see, because they belonged to the visual area, yet did not know what they saw, any more than an infant knows what it sees when it first comes into the world. Though existing in an adult man they had never been taught the meaning of visual objects, any more than his right temporal lobe cells had ever been taught to hear a word, or his right angular gyrus to read a word.

Likewise it has been found that the injuries, technically termed lesions, which produce the various forms of mind-deafness above described, occur only in the left hemi-

spheres of right-handed persons, or in the right hemispheres of left-handed persons; in other words, they show how these mental functions strictly follow the hand most used in childhood, just as the speech centers do.

Hence we learn to know just as we learn to think. We think in words, and for that purpose we register our word memories in their laboriously prepared brain places. So also we register the memories of what we see and of what we hear in their prepared places, the preparation in both instances having originally been begun by the most active hand in response to personal intent. Investigations into infant psychology show that the first training of the sight object center occurs only a little earlier than the time when the cells in the temporal lobe are being trained to hear the first words, for the infant begins its lessons of sight interpretation by stretching forth its little hand to find out what it is which it is looking at. So far back in our lives, however, did this process

begin that we have forgotten all about it; but the saying, "a burnt child dreads the fire," refers to the inscription made by the child on its precuneus that a flame is not like some other attractively shining thing, and that it had better not try again to seize hold of it.

According to the physiological laws which we have already mentioned, memories of all kinds are doubtless registered in our brain cells by the original stimulus of each, and when an agency like conscious purpose systematically repeats the same stimulus to the same cells, they become arranged there in a library of records, as we have shown is the case in the speech centers. There is really nothing incomprehensible in this, for something quite analogous to it all is accomplished in that remarkable mechanism, the phonograph, in which layer after layer of its delicate receptive wax leaves may be found covered with all kinds of sentences, or entire songs with their tunes; while by a device similar to Broca's convolution, there

come back again through its brazen throat the words, tunes, tones, and all else spoken into the machine. An uninstructed Moslem sheikh from Arabia might regard this as an unholy invention of Satan, which of itself produces all that it utters, whereas neither it nor Satan but a human person is the source of every one of its uncanny performances.

From these considerations there can be no doubt that the exercise of every separate mental faculty is conditioned by acquired cerebral changes similar to those by which is interpreted all information coming by the eye and the ear. The brain thus comes to have places where memories are stored for the understanding of each special sensation. But it also follows on anatomical grounds that the human being when he thinks, perceives, knows, remembers, conceives, reasons, purposes and speaks has these powers physically located in only one of the two hemispheres of his brain. As long as the educated hemisphere is in sound condition it matters

little, as far as the mind is concerned, what happens to the uneducated hemisphere. Thus the man mentioned in Chapter IV, p. 63, who had lost one of his hemispheres by disease, happily for him had his speaking hemisphere left intact, and therefore he remained himself in all mental and moral characteristics. Hence his story and others like his in medical literature prove that human brain matter does not become human in its powers until the personality within takes it in hand to fashion it. But for that purpose one hemisphere of the brain matter is quite enough, just as one violin is quite enough for its player, while to the untaught hemisphere is left only what it had at birth, without a word or an idea or a single acquired accomplishment.

This statement, which implies that one of the two human brain hemispheres is normally unintelligent and thoughtless, is unacceptable to some reasoners because it compels the admission that the thinker and his

brain are two separate things, the brain, like the hand, being only the instrument of the thinker. Therefore they search for indications that the silent hemisphere sometimes does come to the help of its highly endowed partner when the latter is disabled in its speaking power by disease—the inference being that it does so by its inherent capacity for speech. But no unmistakable cases of the kind have yet been published, and, as we have remarked before in Chapter VI, those which seem to be so, can easily be otherwise explained. Thus in childhood both hemispheres are equally teachable, and speech lost by damage to one can soon be made up by the education of the speech convolutions in the other. But the age when new languages may be learned varies in different individuals, so that it is not impossible for it to be done in the fifties. If, therefore, an adult is found to have recovered from aphasia after a time, this does not prove that he had two speech centers all the while, for speech is never

an original endowment nor a spontaneous power, but must always be the result of the special training of brain cells. That this marvelous training is practically limited to only one hemisphere is shown by the positive and not hypothetical evidence in hundreds of cases of individuals, many of them men distinguished for mental gifts, who after a stroke causing either sensory or motor aphasia, never regained their lost powers, however long they lived afterwards with an uninjured hemisphere in their heads.

Nor is the problem changed or lessened by referring to the speaking and knowing hemisphere as somehow the "driving" hemisphere, for the question then is what makes it "drive" so wondrously to the utmost ranges of human thought, while its fellow is left unable to know a life companion by sight or to distinguish strains of music from mere noises.

Meanwhile before the advent of this personal agency which deals so remarkably with

portions of human brain matter as to impart to them transcendent properties which they did not have before, nor ever could have spontaneously, the only organizer of nervous tissue which we have met was the Afferent, bringing stimuli from the environment or outside world. But the more we study the processes which result in these mind-linked changes in Man with the same attention which has been bestowed upon the operations of the Afferent, the plainer it becomes that their formative stimuli come not from without but from within, and are essentially unlike the workings of the Afferent. Nothing savoring of purpose or design enters into the play of the Afferent as it flows into the nerve centers with its sensations, any more than the currents of air causing the threads of an Æolian harp to vibrate have any musical meaning comparable to the "airs" of a Verdi. Instead of that the centers organized by the Afferent for work perform that work with no more design than does a watch pur-

posely go when it is wound up. Automatism, pure and simple, is inseparable from the Afferent in every one of its relations. Moreover this afferent mechanism is congenital, entering the world ready-made, without needing mind to work it.

But to speak of a personality which thinks, purposes and wills as automatic, is a self-contradiction in terms. We need not appeal to metaphysics for our argument, because we now meet with another strong line of evidence that the personality can dispense with the most important means of afferent stimuli which Nature furnishes, and yet make good their loss because the personality is independent and self-determining, and hence can triumph over the most serious deprivations possible of its afferent mechanisms for communication with the world in which it lives. This has been shown in some members of our race who have suffered from certain great misfortunes in early life, which, however, constitute in a way most instruc-

tive physiological experiments. To appreciate the force of these demonstrations we must first take into account how much in each case was lost of life's equipment for mental development. Thus it requires some effort to estimate how much education the human mind receives from the single afferent channel of the eye. To do this at all adequately, we must go back to the first news which the child gets from the outer world by sight. A series of impressions, first of color, then of form, then of distance, and lastly of definite objects, are made upon the brain visual area, until by repetition a vast store of picture memories are there laid up for life, as so many object lessons. How much, therefore, is the mind of a young child deprived of, if it becomes blind before this great afferent teacher could give it a single lesson!

But for the education and direction of thought and feeling the human being, different from the lower animals, gains more by

the afferent channel of the Ear than by that of the Eye. The only exception to this law seems to be in the case of birds. Mr. Sclater sealed up the ears of newly hatched chicks, and not one of them could be induced to come to the mother hen who was excitedly clucking to them. The chicks were then placed where they could not see her, and their ears were unstopped, when as quickly as they heard her they ran round to where she was and were soon under her wings. But for the human infant the loss of hearing is a terrible calamity. Besides being at first its only appeal to others, it is itself a relief to the child to cry. Hence, when it cannot hear its own cry, it becomes the more disturbed by its feelings, because loving looks and touch only imperfectly make up for kindly voice, tones and *words.* We must not forget that to a human ear, however young, words soon have some meaning, more than parents may then suppose, until a few months afterwards they are surprised that their children know

so much. If words once begin to reach through the ear, the mind springs forward to its limitless inheritance of thought, and especially of feelings. It is the ear, not the eye, which moves the heart. We see with indifference a fish in its dying writhings, but we cannot listen to cries of pain without emotion. The seeing of the eye supplies the intellect with more ideas than do sounds (not words) which come through the ear. But the intellect informing eye makes more mistakes than all the afferent channels put together in the information which it brings. Its news has always to be revised and corrected by the other senses before it can be accepted. Thus it reports that a man is only a foot high when he is a mile off. But the ear is always accurate. I have recognized a friend's voice when it came over four hundred miles on a telephone wire as plainly as if he had been in the next room. Close the ear, therefore, of a child, and it remains more a mere animal than when any other

avenue with the outer world is closed, because it is dumb.

If we should liken our apparatus for mind-training to a boat which is to take us over the sea of life, the great afferent mechanisms of the eye and of the ear might then be regarded as corresponding to the hull and to the frame respectively. Can the personality, therefore, survive the complete wreck of both, and go on with nothing but the keel to cling to for the rest of the voyage? The answer would certainly be no, if the personality depended, not only for its development, but also for its own origin, upon its afferent mechanisms. If, on the other hand, the Afferent has nothing to do with the personality except to inform it, the loss of the Afferent will have no other effect on the personality than that of leaving it in ignorance. The personality would then be simply like one condemned to solitary confinement. That being so, if only some messages could reach him by any route, however unusual or roundabout, the personality

would be found as complete and individual as ever.

The conclusiveness of this demonstration needs a trained physiologist to appreciate it fully, because he well knows how much each special sense contributes to the mental equipment of a human being, and, therefore, how much is lost when not one, but two, of the chiefest life instructors of the mind are simultaneously lost. It is this which makes the autobiography of the celebrated Helen Keller of such intense interest, regarded purely from a physiological point of view.[1] So important and decisive in their bearing upon the subject of our discussion are the facts illustrated by her story, that we feel justified in dwelling upon them at some length. It is not on account of her becoming such an accomplished woman, with so many eminent men and women among her personal friends and correspondents, that we do so,

[1] The Story of My Life, by Helen Keller. 1903. Doubleday, Page & Co.

but because to a physiologist she is such an instructive "case." Physicians get into the way of looking at patients as so many "cases" of this or that disease, and so Helen Keller fixes the attention of a physiologist not from sympathy, for he has nothing to do with sympathy, but because she is a first-class scientific demonstration. Nothing, therefore, which we will quote from her published autobiography is for the sake of anecdote, but for what it implies about brain matter.

(I do not mean, of course, that physicians have their capacity for sympathy lessened by their pursuits. Dr. Oliver Wendell Holmes was Professor of Anatomy at the Harvard Medical School, and a trained physiologist as well. Helen Keller thus writes (Life, p. 135): "I remember well the first time I saw Dr. Oliver Wendell Holmes. He had invited Miss Sullivan and me to call on him one Sunday afternoon. It was early in the spring, just after I had learned to speak. We

were shown at once to his library, where we found him seated in a big arm-chair by an open fire which glowed and crackled on the hearth, thinking, he said, of other days. 'And listening to the murmur of the River Charles,' I suggested. 'Yes,' he replied, 'the Charles has many dear associations for me.' There was an odor of print and leather in the room which told me that it was full of books, and I stretched out my hand instinctively to find them. My fingers lighted upon a beautiful volume of Tennyson's poems, and when Miss Sullivan told me what it was, I began to recite:

> 'Break, break, break,
> On thy cold gray stones, C Sea!'

But I stopped suddenly. I felt tears on my hand. I had made my beloved poet weep, and I was greatly disturbed.")

When nineteen months old, Helen Keller had an attack, presumably of cerebro-spinal meningitis, which left her totally and perma-

nently blind and deaf, and hence dumb also. Till her seventh year, therefore, she was wholly dependent upon her senses of smell, taste and touch for all her information. Hence, also, she could communicate her wants or feelings to others only by bodily actions which she had learned to associate in her mind with states of pleasure or of pain. On this account she was perpetually subject to fits of great excitement or anger, due to her inner feelings having such imperfect outlets for expression, while she was equally deprived of direction from others. The best of us, though equipped with every means of communication by speech, tone, gesture and glance, with like return of the same from our fellows, are yet apt to be impatient at the slowness of others in understanding us. We can imagine, therefore, what it was to this child to have scarcely any way to explain her wants except by throwing things, or herself, on the ground.

If the Afferent is the origin of mental en-

dowments, her father's pet dog and cat with full possession of sight and hearing, not to mention voice, were in better condition for development than she was. On March 6, 1887, Helen's teacher, Miss Sullivan, arrived, and her first endeavor was to begin teaching the child language by tracing on the palm of her hand the letters spelling the words "doll" and "cake." Repetitions of these word tracings continued until Helen could make them for herself, and by March 31 she could trace on her hand eighteen nouns and three verbs, without knowing, however, what they meant. On April 5, hardly a month from the beginning of her education, the awakening came. Miss Sullivan had her hold a mug in her hand at a pump, and as the cold water filled the mug and ran on her hand, the teacher traced anew the letters w-a-t-e-r on the palm of her free hand. Miss Sullivan writes: "She dropped the mug and stood as one transfixed. A new light came into her face. She spelled water

several times." The great step was gained when this blind, deaf and dumb girl suddenly understood that the symbol traced in her palm meant—water. She had got a word! From that moment her personality was set free, like a prisoner allowed to leave a dark dungeon to go wherever he lists, for now for the first time she knew that everything had a *name,* which she could learn on her palm. "The next morning Helen got up like a radiant fairy. She has flitted from object to object, asking the name of everything," kissing her teacher for the first time in her gladness. It is touching to read that she tried to teach her dog by tracing the word water on its paws. From this beginning her progress was rapid. In two years and a half she was studying arithmetic, geography, zoölogy and botany, and reading general literature. Meantime she was asking questions about everything; and for its physiological interest in showing how a shut-in mind, so to speak, like hers, will work when once in possession of

the Logos faculty, we make this extract, p. 370:

"'Early in May, 1890 (fourth year of her training), she wrote on her tablet the following list of questions: 'I wish to write about things I do not understand. Who made the earth, and the seas and everything? What makes the sun hot? Where was I before I came to Mother? I know that plants grow from seeds which are in the ground, but I am sure people do not grow that way. I never saw a child plant. Little birds and chickens come out of eggs: I have seen them. (All blind persons who have no memory of eyesight constantly speak of *seeing,* meaning thereby correctly enough mental sight, *i.e.,* perceiving.) What was the egg before it was an egg? Why does not the earth fall; it is so large and heavy? Tell me something that Father Nature does.' "

There was no stopping her now. She must know the origin of things. What human being does not ask this question? Does this univer-

sal human trait come from any function of the automatic Afferent, or from the free Personality?

When her teacher in reply (p. 371) told her that "men came to believe that all forces were manifestations of one power, and to that power they gave the name God, she soon asked, 'Where is God? Did you ever see God?' I told her that God was everywhere, and that she must not think of Him as a person, but as the life, the mind, the soul of everything. This pantheistic talk did not suit Helen. She interrupted me: 'Everything does not have life. The rocks have not life, and they cannot think.' "

In March, 1890, three years after she began with her first word, she commenced to take lessons in articulate speech. On account of their complete illustration of physiological fact, we will quote a few passages in which she relates her experience in learning how to make Broca's convolution do this work. (Life, p. 60.) "I shall never forget the sur-

prise and delight I felt when I uttered my first sentence, 'It is warm.' True, they were broken and stammering syllables, but they were human speech. My soul, conscious of new strength, came out of bondage. . . . No deaf child who has earnestly tried to speak the words which he has never heard,—to come out of the prison of silence, can forget the thrill of surprise which came over him when he uttered his first word. Only such an one can appreciate the eagerness with which I talked to my toys, or the delight I felt when at my call Mildred [her little sister] ran to me, or my dogs obeyed my voice. . . . But it must not be supposed that I could really talk in this short time. I needed Miss Sullivan's assistance constantly in my efforts to articulate each sound clearly, and to combine all sounds in a thousand ways. Even now she calls my attention every day to mispronounced words. All teachers of the deaf know what this means, and only they can at all appreciate the peculiar difficulties with

which I had to contend. In reading my teacher's lips, I was wholly dependent on my fingers. I had to use the sense of touch in catching the vibrations of the throat, the movements of the mouth, and the expression of the face, and often this sense was at fault. In such cases I was forced to repeat the words or sentences, sometimes for hours, until I *felt* the proper ring in my own voice. My work was practice, practice, practice. Discouragement and weariness cast me down frequently, but the next moment the thought that I should soon be at home and show my loved ones what I had accomplished spurred me on. 'My little sister will understand me now,' was a thought stronger than all obstacles. I used to repeat ecstatically, 'I am not dumb now'!" "Words are the mind's wings," as she wrote to Dr. Holmes.

Helen Keller's story of her life begins with a child in her seventh year, with each of the avenues of incoming and of outgoing speech closed to her. After two months language

begins with one word lodged in her consciousness by a most circuitous brain path. The book ends with a young woman, a graduate with honors of Radcliffe College, versed in the sciences taught there, along with extensive reading in Latin, Greek, French, German and English classics, passionately fond of poetry and of history, a writer of the purest English style, and a thinker of no mean order, as is sufficiently illustrated by a remark of hers (p. 295): "Toleration is the greatest gift of the mind; it requires the same effort of the brain that it takes to balance one's self on a bicycle."

But, as we have already remarked, the physiological interest of her story is quite apart from the interest of her biography, great as that is. To a physiologist it is an example of a living brain, with the cells of the great visual area entirely and forever atrophied or wasted away, because that is what happens to those textural cerebral elements in cases of her kind. No word for reading could ever

be registered in her angular gyrus, nor in any neighboring visual cells. And just the same extinction of hearing cells was present in her temporal lobes, so that not one was left there to catch the sound of a word any more than that of any other sound. Broca's convolution for uttering speech, therefore, could not have had a single "telephone" wire coming to it from either of these two great afferent centers. After a while Broca's convolution began to be rung up by thousands of reiterated messages coming from a wholly unusual quarter in the brain, namely, the center of the sense of touch. "Practice, practice, practice," by the hour at a time—the work of an indomitable personal will—finally makes that convolution submit to this perpetual stimulation from the tactile area, till it becomes ready to do what Helen purposes, whether to speak, to read aloud or to write.

Now it happens that the sense of touch is the most diffused of all the senses at the surface of the body, so that it is not localized in

one organ, like the eye or the ear. On that account it is the least specialized of any of the senses, so much so that its anatomical seat in the brain center is even yet not fully demonstrated. By itself, therefore, this sense could not afford the mind much definite information. But personality with a purpose can specialize anything nervous. The United States Treasury paid a high salary to a man on account of the one fact that while he could count gold pieces by the hundred thousand with great rapidity, he would instantly toss out either a defective or a fraudulent coin, because for such detection his touch was infallible.

In normal individuals Broca's convolution is in constant communication with the afferent speech centers, those of the ear and eye respectively by numerous nerve fibers passing between them with just that function. This is proved by the occurrence of many instances of word-deafness or word-blindness during life, in which after death the injury

was found not in the gray matter of the convolutions, but in the track of the white fibers leading from them. It is difficult on that account to decide in some patients with aphasia whether the damage has occurred in the gray cortex or in the subjacent conducting white matter, for the effects would be much the same in either case. Normally, however, there can be but very few if any nerve fibers connecting Broca's convolution with the area of the sense of touch. How are we to suppose, therefore, that in Helen Keller's case the afferent speech which she learned through the sense of touch made such abundant connections with the speech-uttering center, that she could talk to others in all the ways characteristic of the function of Broca's center in ordinary persons?

We have to mention now in explanation certain facts about nerve fibers which we have not alluded to before. A nerve fiber is really a prolongation or part of the nerve cell from which it originates, and is itself

as much gray matter as the cell to which it belongs. Now one of the most important facts about these fibrils of gray matter is that they can grow, and that they grow in the direction of the stimulus which courses through them. Thus, if a nerve be cut so that the two severed ends remain at some distance from each other, in a few weeks it is found that new nerve fibers sprout out of the stump end nearest the source of its origin until the gap is bridged. This property is taken advantage of in surgery to restore the sensibility and mobility of a part when that has been lost by severance of its nerves. Hence while it is true that such regeneration does not occur apparently in the conducting fibers of the brain itself, yet there is no improbability in the surmise that repeated currents of stimuli will in time project, as it were, new tracts of fibers from one cerebral convolution to another, for that would be only in keeping with facts already ascertained of the development of great and important tracts of ner-

vous fibers as a child grows. Thus, in the human infant at birth, the great pyramidal tract, as it is called, which connects the motor area of the cerebral cortex with the spinal cord, and by which all voluntary movements are executed, is far less developed than it will be four years later. As the child by practice learns to use its hands and feet, new nerve fibers by the thousand grow from the motor center of the cortex, to go down and make connections with the motor centers of the spinal cord. Such, moreover, must be the case in the organizing of the speech centers in the speaking hemisphere of the brain. If either the reading angular convolution, on the one hand, or the word hearing temporal convolution on the other, had no fibers developed for connecting them with their corresponding speech uttering convolution, as well as with each other, the person might read or hear words, but could not speak at all, a fact clearly demonstrated by *post-mortem* findings, in

which the brain injury has been limited to the conducting fibers of Broca's convolution only, the speech centers themselves being intact. But this capacity for sending forth new fibers to make connections diminishes rapidly with age; hence, when an apoplectic clot ruins the speech centers after sixty years of age, the loss of speech is almost invariably permanent, because the corresponding speech convolutions in the other hemisphere not only are unable separately to learn their words, but the power to generate new connecting fibers between the convolutions, which is equally necessary for perfect speech, is no longer available.

Another important conclusion is led up to by these facts, namely, *that we can make our own brains,* so far as special mental functions or aptitudes are concerned, if only we have wills strong enough to take the trouble. By practice, practice, practice, as in Miss Keller's case, the Will stimulus will not only organize brain centers to perform new func-

tions, but will project new connecting, or, as they are technically called, association fibers, which will make nerve centers work together as they could not without being thus associated. Each such self-created brain center requires great labor to make it, because nothing but the prolonged exertion of the personal will can fashion anything of the kind. A person, therefore, acquires new brain capacities by acquiring new anatomical bases for them in the form both of brain cells, which he has trained, and of actively working brain fibers, which he has himself virtually created.

But nothing could show better than these facts the complete antithesis between personality and automatism. One might as well insist that because an automobile carriage goes along smoothly and mechanically, that the driver, who makes the vehicle turn any number of street corners, must also be an automaton, as to say that a person who educates his brain is himself the

automatic product of the brain which he educates.

This series of facts which we have been reviewing demonstrates how the different places in one hemisphere come to subserve their mental functions by a process of education carried on throughout by one and the same teacher, for the process itself never varies. Moreover it is plain that these highly educated areas in the cortex are not self-taught, because they would not exist only in one hemisphere when the capacity for such education was certainly originally equal in both. But what is that teacher, and whence does he come? It is not easy to suppose that any part of the brain itself can act as such a general teacher, because no cortical area ever interchanges its capacities with any other. If the ear grows dull of hearing the eye cannot help it hear better, nor can the cuneus, while indispensable for the education of the word seeing angular gyrus which is a part of the visual area, furnish a damaged music

center in the temporal lobe with a single note. But so persistent has been the hunt for some cerebral place which created the personality that, since the rest of the cortex has been shown to subserve merely sensory and motor functions, it has been suggested that the limited portion called the prefrontal lobe (see Plate I) is the special mind seat in the brain.

As this region differs from the rest of the frontal lobe in having no relation to motor, and equally none to sensory functions, so that it shows no signs of anything in particular when experimented upon, it has been surmised that it is related in its function to pure thinking, or to the mind itself. It is also claimed that it is more developed in the human than in any other brain. The chief reliance for the support of this theory, however, has rested upon reports of the effects in man of accidents, or of tumors, or such like damage to this locality, upon the mental functions. It is alleged that those who have suffered from lesions of this sort often change

in disposition, with a special enfeeblement of the power of attention and of thought concentration, along with consequent apathy or mental dullness amounting sometimes to dementia.

But just such mental symptoms often accompany damage to other parts than this of the brain, and all are equally susceptible of interpretation on the supposition of consequent derangements of the cerebral circulation. But to demonstrate that injury to the prefrontal region directly causes these mental symptoms, they should uniformly accompany such physical changes. This is so far from being the case as to lead Professor Schäfer to remark:[1] "So much has been made of certain clinical cases in which an extensive lesion of the frontal lobes was followed by diminution of the intellectual faculties, and by a change for the worse in the general disposition of the individual, that it is important to ascertain what the clinical evi-

[1] Textbook of Physiology, vol. ii., pp. 772–773.

dence on this point really amounts to. Welt has collected fifty-nine cases of lesions confined to the frontal region in man; of these forty-seven, or about 80 per cent., showed no changes in intellectual capacity or character; and only twelve of the total number, or 20 per cent. had such changes recorded against them. It is clear, therefore, that the doctrine of special localization of the intellectual faculties in this portion of the frontal lobes rests on no sufficient basis."

On p. 63 is given the particulars of the man who had one hemisphere, and particularly its frontal part, destroyed by disease, without affecting his mind at all. Fortunately for him, it was his wordless and not his word endowed hemisphere which was involved. Likewise a great difference is found in the accompanying mental derangements of frontal lesions, whether they occur in the wordless hemisphere, when often there are no mental symptoms at all, or in the educated half. For the purposes of our argument, we might

readily admit that the frontal convolutions can be taught important mental functions, just as areas in the occipital and in the temporal convolutions are thus taught. But until it can be shown that the frontal convolutions think at all, whether they have been taught or not, that is, that the frontal lobes of both hemispheres work the thinker, all these speculations about them are vain. It is not improbable that the prefrontal convolutions of the educated hemisphere do play an important part in mental operations, but that does not show that they are a whit less instruments than the angular gyrus is in its reading function, or Broca's convolution in its function. Of the four strings of a violin, string A is struck oftener than string G to make music, but string A does not make the other strings play; much less is it itself the musician.

From some examples in my own experience I would infer that one of the functions of the prefrontal convolutions in the speech hemi-

sphere is the recognition of personal identity. A gentleman once consulted me in my office about some nervous symptoms. For reasons unnecessary to detail here I began to suspect that he might be suffering from the effects of a brain tumor, but the most careful examination failed to show that any one of his special senses, on being separately tested, was affected in the least, nor could I find any motor derangements. His speech was well articulated, and he expressed himself clearly. Suddenly he said: "Where am I? Am I here or somewhere else? Am I in the body or out of it?" These remarks confirmed me in my suspicions that the probable seat of the lesion was in the left frontal lobe. Some months afterwards my surmise was proved correct at the autopsy, when a tumor was found in that very place.

We may remark here that the facts about the marvelous processes of education of the speech endowed hemisphere naturally suggest the question, whether the elaboration of

so many interpreting or association areas, with their consequent maze of association fibers, would not in time increase the actual amount of gray matter and its fibers in those localities where special work has been spent upon them by the individual.

This may be difficult to demonstrate by our present imperfect methods of physical inspection of nervous matter. Though functionally the difference is wide enough between a purely sensory and a purely motor nerve, so far we are unable to *see* which is which, and we have to irritate or to cut them to find out. So no inspection of the gray matter of the speech centers tells us any more of their very special powers than the inspection of any other locality in a given cortical area reveals what it does or how it does it. About the only physical sign of the kind yet demonstrated is the presence in the motor area of the cortex of relatively large and stellate-shaped cells which resemble in these particular respects the cells at the origin of the

motor nerves of the spinal cord. But all analogy with other living textures would lead us to infer that the more a part was exercised, the more it would grow in its special components, and hence that the cortical layers of a man, sharing fully in all the mental activities of modern civilized life, would be more developed, even quantitatively, than the thoughtless brains of a Papuan savage. The only way in which such increased brain growth could occur in the cranial cavity would be by increased folding of the gray cortex, with multiplication of its associating fibers. A few investigations of the kind have been made of the brains of men distinguished for varied mental acquisitions during life, and when compared with the brains of savages or of men of low or abnormal intellectual grade, they seem to show, though with some exceptions, that in the speech centers especially, the brains of highly cultivated men present much greater complexity in the convolutions, with greater depth of the fissures.

But though further investigations may demonstrate fairly constant *post-mortem* evidences in the form of increased cortical convolutions of a long life of exceptional mental activity, this would not prove at all that their subjects became eminent because they were born with such convoluted brains. While it is doubtless true that all individuals of our race are not born with equally good brains, yet the fact remains that the special mental capacities for which certain men have become eminent were all acquired and were not congenital. Hence the utmost which can be conceded is that the greater aptitude for acquiring may be congenital, but nothing more; because however apt a man may be in learning languages or in mastering mathematics, he did not know a word, nor could he count two when he was born, and if it had been possible to examine his brain when he was four years old, there would not have been found a single one of the complicated brain folds which he had when he was sixty, because he

made all these latter himself by persistent exercise. In other words, a great personality may possibly make a great brain, but no brain can make a great personality.

To sum up. Our subject deals primarily with material facts. Hence it is in no sense a speculative subject, because anatomical details are neither speculative nor theoretical, and we have been concerned with the anatomical seats of mental faculties. We began with the physical anatomy of the faculty of speech, which demonstrates that the reception, the understanding and the expression of words depend as absolutely upon a special brain mechanism as the movements of the hands of a watch depend upon the spring inside. But much more than that, the particular anatomical seats of human intelligence are just as palpably demonstrable as the seats of human language. These so-called " mind " areas of brain matter are found grouped around the congenital sense areas, and it is by them that the human being knows what to think

about the information which his senses bring. Cut out any one of those areas, and forthwith its kind of *intelligence* is gone.

The most materialistic theory of the relation of thought to brain substance could not ask for more solid facts to support its contention, if only it could be demonstrated that these brain localities, with their matchless endowments, were as native to the brain as its sensory centers are. But no human being ever brought with him a single one of these wondrous places in his brain, nor ever inherited them. Yet their existence must somehow be accounted for. No question about physical life equals this question for surpassing significance. Not being native, that is, congenital, it follows that these seats of mental faculty must all be artificially acquired. It is equally plain that the process by which they are acquired must be the same for them all, however different their functions be, because as an anatomical fact they are all found in only one of the two hemispheres.

This feature, therefore, puts an entirely new aspect on the whole matter. No longer can we suppose that the pair of symmetrical brain hemispheres in our skulls hold just the same relations to the functions of thought that the two eyes do to the function of sight, or the two ears to that of hearing; because if in a young person one eye be covered, the other eye does not have to wait for months before it can learn to see as its fellow did, nor if one ear be stopped for experiment in a person after fifty, does its companion ear then prove to be totally deaf. Hence, while both members of the eye and ear organs are at all times just alike in their work, it is surely significant that with the two brain hemispheres it is entirely different—so different indeed that no contrast could be greater than that existing between them in their capacity for mental work.

Physicians frequently meet with striking illustrations of this one-sided habitat of the mind. A man who was one of the strongest

thinkers and one of the greatest masters of English style that I have ever known, had his mind totally wrecked one morning by an apoplectic clot. But though he lived for months afterwards with his right brain hemisphere apparently as sound as ever, yet he could not recognize the dearly loved members of his family either by sight or by their voices. His intelligence was simply suddenly annihilated by the injury in his left hemisphere. The fact that his right hemisphere remained uninjured availed nothing, because this exceptional musician had never played with that right violin, and now that it was seventy years old it was no longer musical.

Therefore it is a Power not of the brain, because it is the masterful personal Will, which makes the brain human. By a human brain we mean one which has been slowly fashioned into an instrument by which the personality can recognize and know all things physical, from the composition of a pebble

to the elements of a fixed star. It is the will alone which can make material seats for mind, and when made they are the most personal things in a man's body. In fact they are the only examples of the kind in his physical frame, because, though he cannot make one hair of his head white or black, he can and does make speech centers inside of his head, to say nothing of other centers of most varied faculty. So long as his brain matter has not become " set," as potters would express it, by the lapse of years, he deals with his cortical gray matter by the purposive exercise of memorizing habit, as the potter deals with wet clay. And wondrously does he fashion it, until it no more resembles the same gray matter on the other side of his head in mental capacities, than unfashioned clay resembles a Portland vase. How could this clay itself make this peerless vase?

Considering that it is not brain which makes man, but man who makes one of his brain hemispheres human in mental faculties

we might even say that if a human personality would enter a young chimpanzee's brain where it would find all the required cerebral convolutions, that ape could then grow into a true inventor or philosopher.

CHAPTER IX

PRACTICAL APPLICATIONS

We have definitely concluded that the facts both of brain anatomy and of brain physiology indicate that this organ of the personality is never other than its instrument, while the personality itself is as different and as separate from it as the violinist is separate from, and not the product of his violin.

As already demonstrated, one of the properties of the personal human will is that of being a specific brain stimulus, more potent than all the afferent stimuli together in producing changes in brain matter, by which the brain acquires, and by it alone, entirely new powers or functions not possible in any other animal brain. This great truth would suffice of itself to prove that the Will is a new thing, for the only other fashioner of nerve

tissue is the Afferent, and we have shown that in their fashioning processes the Afferent and the Will are generically distinct, and have no relationship to each other.

Indeed, as a final contrast, we may say that the Afferent can do nothing new any more than a watch can. Whatever a watch does is the result of pre-arrangement in its mechanism. Likewise a nervous center is so slowly organized by the mechanically acting Afferent—evidently requiring the co-operation of heredity for many generations—that it will do only one thing during life and no other. But a Will act, ordinarily called a voluntary act, is not often just the same thing when repeated. The variety of voluntary acts is practically unlimited, on account of a profound principle underlying Will by virtue of its own nature, namely, perfect freedom.

Having recognized what a portentous change comes over the whole situation by the entrance of this highest attribute of personality, nothing could exceed the importance

of showing what, according to physiology, is the rightful place and rank of the Will in a human being. This question of rank is an actual and not a theoretical one in the consideration of any subject in nervous physiology. As we have remarked before, it is only in a nervous system that the element of rank has any place. But there it is all important, because no principle is more fundamental than that of control of the working of all the lower nerve centers by the centers which are higher than they in the scale and in the time of their development. Therefore what is and always should be the governing power in our living selves is a proper subject of physiology as well as of philosophy.

Approaching this subject, therefore, from the side of physiology, we must begin by referring to what is said on pp. 157-9 about Inhibition. It is well for the ordinary reader to appreciate the importance which is attached to inhibition, as its technical term is, by physiologists in their interpretation of

nervous functions. Without inhibition no organization of a nervous system would be possible; and therefore we may explain again that by this term is meant that the operations of nervous centers, instead of being allowed to go on independently, are constantly controlled, restrained, checked, or altogether suspended from moment to moment, according to time needs, by the direct intervention, that is, " inhibition " of other nerve centers, or even sometimes by nerves specially endowed with this restraining power.

We there cited in illustration how the medulla oblongata sends a bundle of nerve fibers to the heart, called the heart accelerators, which make it beat faster, while it also supplies an important strand of nerves which bridle the heart and make it beat slowly and deliberately. But the reader may consult a modern text-book of physiology to find another striking illustration of nervous regulation of the heart, under the title, the Depressor Nerve. Ever since Ludwig and Cyon

first discovered the function of this small nerve in 1866, physiologists have been greatly interested in its unique properties, one being, as demonstrated by its first discoverers, that it can quickly lower the pressure of the blood in the arteries all over the body from 30 to 50 per cent. To understand this it should be stated that in the medulla oblongata there is the center governing the entire and most extensive system of special nerves which ramify on the coats of the arteries, and whose business it is to regulate the caliber of the arteries so that their diameter becomes large or small according to whether the part which the arteries supply needs more or less blood. Thus, the stomach needs nine times more blood when actively digesting its contents than when it is empty, and the vasomotor nerves, as they are called, of its arteries dilate the arteries to bring more blood, or contract them to shut it off, as the need may be. The function of these nerves, therefore, is of prime importance, for without their con-

stricting action the vessels of the abdominal organs alone might relax enough to contain most of the blood of the body, as sometimes happens with quickly fatal results. But, on the other hand, during violent muscular exercise or under excitement, the blood may be driven to the heart so fast that its cavities become dangerously distended. Then it is that the Depressor Nerve instantly comes to the rescue. Ignoring its automatic nature, we may figuratively represent it addressing the medulla thus: "Make haste! Emergency! Heart overfilling and distending so with blood that a valve may give way! Tell your vaso-constrictor center instantly to order all its nerves to relax their grip on the arteries the body over, to the degree which I direct. Order the accelerator center to suspend operations; and the vagus center to give an extra turn to its brakes!" The medulla obeys, and the over-full heart immediately relieves itself by a general widening of its arterial channels. Thus we find this single

afferent nerve capable of inhibiting the action of the whole vast mechanism of the artery constrictors, so that when this nerve has been experimentally stimulated by an electric current, the tongue swells from its arteries being dilated, and likewise the kidneys are flushed red with blood. Also, unlike other nerves, it cannot be fatigued or exhausted by prolonged stimulation, so that in every respect it is like a sleepless, tireless sentinel posted at the great gate of the heart's outflow.

These are only illustrations of the nervous mechanism before there is added to it a single one of the great brain ganglia with their high and complex functions. If in the array of the spinal centers we find at every turn special disciplinary arrangements in the shape of specific appointments, so to speak, of nerve centers with their special nerves to act as checks or controls over the whole system, we will find still plainer illustrations of the function of Inhibition or control in the

great army of cerebral centers. Whole tracts of nerve fibers descend from the brain, coursing along the nervous strands of the cord till each fiber ends at, but not in, a spinal nerve cell. Forthwith that nerve fiber rules the spinal nerve cell absolutely, by directing how it is to act and do this or that according to commands coming from above. The spinal motor cells move all bones of the body by the muscles attached to them, as we have said, but every such movement is subject to the behest of the brain fiber.

But just as there are fibers passing from the brain above to the cord below, so all cerebral collections of gray matter have fibers coursing between them. These, as we have stated before, are called Association fibers, as they pass from lobe to lobe, from lobule to lobule, and from convolution to convolution. That these extremely numerous connections between the cortical centers with each other are for the purpose of bringing the different functions of each into communication and re-

lation with the others, is not doubted by any one. According to all precedent in the nervous system, it follows that this anatomical fact indicates that the great law of inhibition must be the necessary law governing the mental operations of the brain itself. Each thinking center, acting by itself, without being controlled by other centers, would inevitably act foolishly. This is the reason of the absurdity of dreams. In dreams some nerve centers happen to awaken by themselves, and thus start ideas without any control or correction from other nerve centers which are still asleep, and which if they were also awake would tell them: "That is not true; stop, till I think with you!"

The facts of delirium are also best explained as a result of the suspension, through paralysis of their inhibitory nerves, of the control of higher centers over lower ones, which then run riot with their unchecked fancies or ideas. That this is true is proven by the fact that just such disorders can be

imitated by administering agents like opium and alcohol, which, as we know by experiments on animals, have this same property of paralyzing nerve inhibition, whether in the brain or in the spinal cord. A well-balanced brain, therefore, is one which, when some one center starts an idea, waits till the answer comes from all the other nerve centers which have communicating fibers with that center as to what they also think about it.

One other fact also should be mentioned here. "As quick as thought" is a proverbial phrase which a physiologist would not care to use, for he has ingeniously devised means by which to measure the rate of transmission of a nerve impulse both up a sensory nerve and down a motor one, with the result that it averages about 180 feet a second in the first, and 160 in the second instance. Now some have imagined that nerve currents are somehow allied to electrical currents, but while the nerve current vibration travels not more than 200 feet, an electrical current dur-

ing the same time traverses a copper wire at the rate of 180,000 miles a second. Between the two, therefore, there is a greater disparity than between the fastest of express trains and the slowest crawl of a snail. More than that, when an afferent stimulus reaches a nerve center a marked delay occurs before an efferent response emerges from that center. As Sir Michael Foster expresses it: "The advent of an afferent impression by the afferent nerve is a busy time for the center, during which many processes, of which we have very little exact knowledge, are being carried on in it." It takes some time to deliberate what it will do. The shortest period of a reflex act has also been measured in a few simple reflex arcs, only to show that the delay at the center exceeds in time both afferent inflow and efferent outflow. Hence when several nerve centers have to adjust themselves to know what they are all to do about some afferent excitation, one center sometimes inhibiting the other during the

process, the final outcome may seem to be a very deliberate affair. Without knowing it, therefore, a man may have good physiology in his exclamation,—" If only I had stopped to think!"

But to return to the subject of the physiological rank of the Will. As we have explained before, the higher centers do not suppress or abolish the functions of the lower centers, but restrain, regulate and direct them instead. They, in fact, establish their prerogative to govern by governing, and when needful they soon prove their title by doing so.

We have already demonstrated the mighty work of the will in dealing with brain matter as the potter does with clay, and that it is the will alone that has that power. But on that same account we are now to show that in thus making an instrument for the mind to use, the Will is higher than the Mind, and hence that its rightful prerogative is to govern and to direct the mind, just as it is the

prerogative of the mind to govern and direct the body. No teaching of physiology is more important than this, and its truth is emphasized by the great facts of human life which themselves both illustrate and confirm it.

Thus the rule is universal that the higher in rank is responsible for the behavior of the lower. Hence it is that with the advent of the human Will there enters a principle into the living world which is entirely new, because nothing like it is recognizable anywhere else. This principle pertains, and is applicable, to man alone, and not to any other creature on earth. So transcendent in its bearings and applications is this principle, that we may well pause to note what it implies about the real nature of the human will, because, owing solely to what his will is, on man alone rests the weight of Personal Responsibility. Therefore man himself cannot possibly be a living machine, however much his mind may answer to that description, for no machine can be responsible for anything, because a

machine can do only what it is constructed for. Nor can a mere animal be held responsible for anything, for even though it be high enough in the scale to have a mind, and some animals certainly do have minds, yet they are virtually so fully the creatures of the mechanical Afferent that they have no true power of choice. But man *can* always do or not do as he chooses, or, in other words, wills. Therefore this very different thing, his will, makes him different from every other earthly living thing. Therefore something is expected and taken for granted about him, which is not expected of any other being. In fact man reigns here below only because he is responsible, and it is his will alone which makes him responsible.

Human responsibility, on account of man's possession of a virtually all-controlling will, if he chooses to exercise it, is such an unwelcome doctrine to many reasoners that every effort has been made to disprove the freedom of the will. We, however, cannot follow this

contention when it travels off into the far fields of metaphysics, except just enough to enable us to bring the disputant back to our province of physiology.

Thus it is contended that the human will is not free because it is itself the product of motives. As Spinoza expressed it, "men are free as to their acts, but not free as to the motives which determine these acts. A motiveless will is no will at all, because a will can act only as it has a motive or motives, and, therefore, it cannot exist apart from motives. Hence, as it is the motives which make the will, man's will is not free, simply because it has to submit to the strongest motive."

The fatal flaw in this reasoning is that it confounds a thing with the conditions of a thing. One might as well deny the power of steam, because it cannot do anything without first being confined within the sides of a boiler, as to deny the power of the will because its operations are always conditioned

by motives. A steam engine may be a perfect engine, but it may work very feebly if it has not enough steam. So a man may have and may appreciate to the utmost, all the motives for a given line of conduct, but may weep, not because of lack of motives, but from lack of will power to act upon those motives. In our concluding chapter we will allude to a great physiological reason for this too frequent lament.

But, after all, the practical experience of human life is the best test of the truth of any theories, and especially of metaphysical theories. Men have never doubted the fact of human responsibility, nor the reason why every man is responsible.

One illustration of this truth will suffice. Go into any court of law on earth, whether in America, in Europe, in Turkey or in China, and see there the criminal and the judge. Can the criminal in effect say anywhere or in any language, " O Judge, you should not punish me, a poor machine, whose efferent

acts are the necessary result of my afferent impulses! Think in my case how old, how hereditary and natural the afferent impulse was. I was starving, and in order to eat I stole." The reply of any judge the world over to such a plea would have to be the same, for there is one human fact upon which all human law is based. It assumes that there is a central power in every man which must be stronger than impulse, whether single or multiform, and that men must be punished if it is not thus stronger. The judge, therefore, answers to such pleading: "You are a man, and so have the power of choice. However strong and however numerous or sudden the impulses of passion or the cravings of nature may be, you still have within you the ability to choose not to yield to those impulses, and on that account alone I am here to judge you. If you did not have that power, I could have no jurisdiction over you. If you were a mere animal, a noble lion or a cunning ape, or anything like them, you would

not be brought here before me whatever you did. But because you are a man, and as a man have the power of choice, you now find yourself in court, because when you were hungry you did not act like a man but like a hungry animal, and you shall be punished because you did act like an animal."

This illustration is enough to prove at once that the power of choice, or, in other words, the Will, in man, cannot possibly be mechanical or the product of afferent impulse, because it is plainly above impulse or else it would not be expected always to rule impulse. Therefore it must be free from the tyranny of the Afferent, for if it were not thus free, there would be no responsibility; and if there be no responsibility, then there can be no human law whatever. To admit that this principle can ever have an exception in law, whereby impulse could ever lawfully become stronger than the will, would be forthwith the abrogation of all law. Law's very existence depends upon the responsi-

bility of men, because they have a will which always ought to be the master and not the slave, still less the product of afferent impulse.

Such being the presumption of all human law about the rank of the will as regards conduct, what do the facts of human life in general testify as to the relative station of the mind and the will? Chief among the faculties of the human mind are memory, imagination, speech, knowledge, conception and judgment; this last leading to the mind's highest attribute, Reason. No wonder that these splendid endowments should lead many to think that there can be nothing higher in us than the mind. But in the order of development, physiology emphatically states, and the whole world proves it to be true, that the mind is not only the subordinate, but well nigh invariably the merest servant in man of the will, and by it often as despotically ruled as the mind in turn often despotically rules the body.

One proof of the secondary place held by the mind, the significance of which is often not sufficiently appreciated, is the fact that the mind is easily detached from the personality, while such is never the case with the will. The mind is so detachable that it can be made to work like any other machine, as its owner sees fit. A prominent body of professional men among us live by letting out the entire equipment of their mental faculties for hire. After a lawyer has accepted a retainer, he commands his mind forthwith to busy itself with all its resources of reasoning and of persuasion for the party who pays him. Even his emotions, from the extremes of pathos to those of indignation, may be pressed into the service as well. But no man can let out his will for hire, and he lies when he pretends to. The will refuses to be displaced from the personality by anything on earth, or sometimes in heaven.

But this subject wears a grave aspect when it is recognized that, owing to its original pre-

rogative, the Will always holds a retainer on the Reason in practical life. The Reason may sometimes timidly propose to its master a series of arguments which it knows will not be welcome, only to be ordered to come back again with a more acceptable line of "reasons." It is this fact which explains why opinions, either political or religious, can and do have well-defined geographical rather than mental boundaries. The Strait of Calais is like a rivulet compared to the historical separation between the English and French views; while as to the Strait of Gibraltar, Morocco is much farther away from all Europe in every belief and principle than Japan. But one especial historical illustration of this truth we had in America. Before the year 1861 a boundary, called, after two surveyors, Mason's and Dixon's line, divided the United States, not only geographically but politically, intellectually and morally. Notwithstanding all the sophistries about other issues, there lay, as Lincoln said in his im-

mortal second Inaugural, as the chief cause of all the fierce antagonism between the two geographical sections of the country, a difference of opinion about the institution of African slavery. Was it because the reasoning faculties differed so between these two sections of the same English-born race? On one side of the line most men and women reasoned, and so supposed that they believed, that slavery was the sum of all evil; on the other side, most men and women reasoned, till they supposed that they believed, that slavery was a good, if not a divine, institution. Nor was the dispute settled by reasoning.

Some would-be reformers or philanthropists appear to rely upon increase of knowledge or of information in the world as the cure for the world's evils. If men's minds were but enlightened, then everything would go well! The physiologist can only point out that such people, owing to their unfamiliarity with the constitution of this court, are addressing the wrong official. Reason undoubt-

edly does hold a high position at this court which no one can justly disparage, but at best it is only an adviser of its sovereign. In the future, as this master improves in motives, this official will doubtless be promoted with an increase of authority. But as the world is still constituted, the influence of Reason with the power which actually rules is at all times uncertain, because the effect depends on how the ruler is otherwise disposed. Should the Reason venture to be importunate, it meets with the summary answer of the Roman Cæsar: *Sic volo, sic jubeo, stet pro ratione voluntas* (So I will, so I command: For a reason let the wish stand)!

Therefore gain the ear of the Will first, and everything naturally, because physiologically, follows. The world is to improve, not by an increase of knowing people (desirable as that is), but by an increase among its inhabitants of people with benevolent wills.

One phase of this subject deserves notice. Though the mind is so detachable from the

real self, men nevertheless are constantly liable to confound it with the self. No mistake is greater and yet so common. Thus when on occasion this retained lawyer of the will is directed to reason and to talk volubly on all righteousness, men are deceived into believing that those who can talk so well must *themselves be good.* Both Seneca and Lord Bacon were among the meanest men of their bad times. The Roman's Moral Maxims are admired to this day, but he was the man who scandalized even the hardened cynics of Nero's Rome by rising in the Senate to eulogize Nero for ripping open the body of his mother to see the womb that bore him. Indeed some men may be observed who, for the creditable showing virtuous declamation makes, proceed to display their own gifts of eloquence about goodness, much as they would lead out a horse to show his fine points.

Another important aspect of the relation of the Will to the Mind is that just as with the creation of speech centers, the will like-

wise so alters the brain that in time the brain thinks only according to certain habitual ways. Some strong but elderly men of my acquaintance, whose reasoning powers no one could pronounce weak, seem no more able to change their opinions than they could learn readily Turkish or Chinese. As a rule, it is only in the third or fourth decennials of life that men's minds show any capacity to be "converted" on any important matter of opinion. The cause for this is not from any enfeeblement of judgment attendant on the advent of middle age. Instead, the judgment as a faculty should then be much stronger than in youth, as indeed it generally proves to be if left free to act. But as the years pass, the judgment is less and less free to act. Those will elements, likes and dislikes, in proportion to their intensity and duration, have steadily been fashioning the mind's physical instrument to work out only opinions to match, until to have new opinions they need to have literally new brains. The

utmost that reason at any time can do is to persuade its master by adducing other motives, but an adult man who can be convinced against his will is well nigh a physiological impossibility.

Why this is so we now see clearly. It must not be supposed that men ever really hold opinions which to them appear unreasonable. Their wills take good care that their reasoning servant should always supply them with all the reasons which they want, and very well does this servant furnish its master with most cogent arguments to show the great "reasonableness" of his views, especially if his master's interests, that is, wishes, are strongly enlisted.

Men's interests come to them from such sources as their parentage, birthplace, party or sect, and the influences of these factors in life sway their reasoning as naturally and irresistibly as the wind carries with it the dust of a road. This subservience of reason to the will is simply physiological, and there-

fore so unconscious that it is in no sense hypocritical or insincere, however some may wonder at the intellectual feats in reasoning of those who have differed from them, not in mental faculty, but in their native environment. No one should wonder at or resent any reasoning as such, for this subordinate in man has to do as he is bidden by his master. In short, the world has yet to learn, once for all, that men are not to be justified nor condemned by such superficial things about them as their opinions. Set the will right first, and men's opinions will follow suit, as soon as they have opportunities for knowing better; but with the will remaining perverted, not the opportunities for knowing of an eternity will avail.

One of the best promises for the future of our race is the fact that men are always touched, and the longest affected, by the spectacle among their fellows of an individual life of consistent goodness, itself due to a will attribute. Influence is an exclusively

human word, and, in this world of changes by death, it is to be measured not alone by its extent, but by its duration. Judged thus, the influence of a simple-minded but loving mother may be perpetuated long after the eloquence of a score of famous orators has died away; died away as only mind-produced words can utterly die away into empty space.

Passing from the general to the individual, no subject should so commend itself to the serious attention of all educators and instructors, as those physiological facts which explain how the mind acts, and how the will acts. Every teacher and parent ought to learn all that they can about this subject. The thinking brain when left to itself is the seat of the play of the Afferent, responding mechanically to a thousand thousand afferent excitations pouring in upon it, in number as countless as the birds of the air which come down from the north, south, east and west, on a field in Gennesaret to catch away the seed of the sower. We are not responsible for the

thoughts which enter our minds. No man ever was. What we are responsible for is the thoughts which we allow to stay there, because we have a kingly power within us which can command this mechanically thinking brain to do its thinking according to its behest; just as the brain in turn can command the spinal cord to stop acting reflexly to its afferent excitations, and to act only according to the brain's behests. The Will, by its lawful, physiological, inhibitory power, can say to the thinking brain, these thoughts are good thoughts and valuable, therefore keep them; those other thoughts are purposeless and hence unprofitable, therefore dismiss them at once; and a well-disciplined mind will obey.

With what result? Here we come to the highest illustration of that great principle in nervous development, Discipline, for it is the Will, as the ranking official of all in man, who should now step forward to take the command. We cannot overestimate the priceless

value of such direction when completely effective, for the life of the individual in this world. A mind always broken in to the sway of the will, and therefore thinking according to will, and not according to reflex suggestion, constitutes a purposive life. A man who habitually thinks according to purpose, will then speak according to purpose; and who will care to measure strength with such a man? Such a man or woman is the very embodiment of living power. But the important practical truth to apply here is that no power so grows in us by exercise, or so weakens and atrophies by disuse, as the will. Teach a child self-restraint, and you are directly developing thereby his will power. Soon he will himself learn the next lesson in will development, and win Carlyle's great equipment for life, the ability to take trouble. But physiology now adds that the will then alters the brain by creating new places for the mind to work with. It is the will which creates the man.

When the age of three score is reached, men can give the best opinions about life, because most of its illusions have vanished, and well can they then comment on many a fellow traveler's course, though they may not care to refer to their own. Not a few of those whom they have known started out apparently well equipped, so far as mental gifts and opportunities of education and of social position could enable them to go far and ascend high. But one by one they lagged and suffered themselves to be outstripped by others, whom perhaps few suspected at the start would reach the first rank before them, because they appeared so much inferior in mental powers to the men whom ultimately they wholly distanced. Will direction explains it all. What is the finest mental machine in this life without will power?

In a former age men worshipped the body. Homer's heroes, with the partial exception of Ulysses, were worshipped for their bodily strength and beauty. The same is still true

everywhere among savage tribes. But we are living in an age in which mental gifts are estimated above all else. The great poet, the great artist, the great writer, the great orator, are our Goliaths, while there is no end to the twaddle about genius.

But the finest mental machine without the will is little else than a machine worked by the Afferent. But we are not here to be afferent. It is a responsibility for any being in the universe to have what man has—the Will. That majestic endowment constitutes the high privilege granted to each man apparently to test how much the man will make of himself. It is clothed with powers which will enable him to obtain the greatest of all possessions — self-possession. Self-possession implies the capacity for self-restraint, self-compulsion and self-direction; and he who has these, if he live long enough, can have any other possession that he wants. The steady discipline of the will saves the mind also by obliging it not only to lessen the number of

its thoughts, but to improve their quality. It is a weak, often a diseased mind which thinks hurriedly. Let a man be enfeebled by a fever, or by any other cause of exhaustion, and he has hard work to keep his mental machine from turning out thoughts which run to the end of the earth. A rapid flow of ideas, indeed, is the sign often of impending ruin, as in the approach of maniacal insanity, and rarely does that dreadful calamity occur except after long antecedent, vicious mental habits, in which the mind has been allowed to roam with progressively less and less inhibition by the will.

To a less but ever harmful degree men are everywhere exposed to the depredations of that great thief of life—Desultoriness—for desultoriness of thought leads to desultoriness of purpose, of plan, and of action, because each of these are soon displaced by some other thought or purpose, till the man wakes up at last to find his life wasted by his ever roving, afferently working mind.

Mental waste from too little will direction is the greatest waste of the world. Will direction calls for effort, but without it the mind can easily saunter among attractive scenes of its own creation. This is one reason why our world is infested with so many dreamers, because it is so interesting to imagine an ideal society, an ideal state, or an ideal church with personally owned air castles included. All these are examples of mental processes which, when indulged in till they become mental habits, may end in true mental diseases. During the usually gradual onset of that fatal form of insanity which ends in general paralysis, the mind of the patient is characteristically occupied with exalted day dreams. I have thus recognized paupers in almshouses as affected with paresis, not only by the physical signs in their eye pupils, etc., but by eliciting from them confidential statements of what millionaires they were, and what great things they were going to do.

It is therefore one of the healthiest symp-

toms in a man to find him always able to face facts. This the mind will never do without the command of the will, because facing facts has to be a deliberate, often a disagreeable process, requiring much thought; and no mental machine can think long on any subject unless it has learned to think by will. Deep thought is but another term for prolonged thought.

Without at first proposing anything of the sort, the physiologist now begins to find himself appearing in public in the conventional garb of an old sage. From the time of the prince who, centuries before Moses was born, wrote a book which has been found in an Egyptian tomb, in which he counsels his grandson how he could profit, as he himself had, by studying the books of the ancients, through a long line of Hebrew, Sanscrit, Persian, Chinese, Greek and Roman worthies, mankind has been abundantly lectured about wisdom. Some people find these sages rather tiresome, because their talk is so monoto-

nously alike, while its substance nearly every one has known before. Therefore the physiologist had better not venture to add himself to the number, unless he can show cause by having something new to say. All that he can claim is that his calling has made clear certain facts and principles entering into the question which his predecessors might have suspected, but without being as well informed about the grounds for them as he now is. Thus as to wisdom. For practical purposes it might be defined as a correct appreciation of the relative importance of things, and acting accordingly. The physiologist divides this definition into two very distinct halves, according to his recognition of the wide difference between the mind and the will. The first half, the appreciation of the relative importance of things, is done exclusively by the mind; and it does it so well and easily that any one can try his hand at it. Everybody is wise—by fits. The greatest fool of one's acquaintance has his sage moments,

and, moreover, can deliver correct judgments about what others ought to do. But when it comes to acting accordingly, it falls to the will alone; and to keep on steadily doing what the mind recognizes as the wise thing, such a store of will power is needed that but few are found who have it.

The ancient sages long bewailed this failure of the will to do the behest of the wise mind; but though they clearly recognized the fact, they did not know the physiological reason for it, which we are yet to allude to in our final chapter.

As we have stated in Chapter I, none of them knew what a nervous system was, nor what the brain was for. They did not know, therefore, any of the following facts which have so much bearing upon every speculation about man. First, that the conscious personality has a material organ to think with, which exists in two symmetrical halves. It is only one half of this organ, however, which can be used for speech, or for recog-

nizing or knowing anything which is either seen or heard or touched, in the sense of the touch which is educated. All *acquired* human endowments, therefore, are acquired by a modification of the material comprising the speaking half of the brain. This speaking half of the brain did not originally have a single one of these great functions, not a single place in it for them, any more than its fellow hemisphere has to the end of life. They are all stamped, as it were, each in its respective place in the speaking hemisphere, by a single creative agency. Had any one of the old wise men or philosophers been told this, how eagerly would he have asked who or what that creative agency was! We can well imagine that when told that it was alone the purposive human will which first endowed that hemisphere with the great faculty of speech, and then with all the rest of these great powers, he would have exclaimed: "If so, the Will is the greatest fact in man!"

The physiologist has something new to say

even on the oldest subjects of the moralist. Who, like himself, for example, can speak with such emphasis on the great subject of Habit? Long ago sages said that our habits make us. But they said so after their observation of external life. The physiologist, using the same words, means that our habits make our brains inside of us, so that we think, talk and act accordingly, and always accordingly, until the Will steps in and takes the fashioning of the human brain in hand.

But has the Will here entirely displaced Habit? Alas! no. The Will is very partial in its work on the brain. As it began by discarding one of the two brains altogether, so by analogous neglect it also leaves every man with a great part of his mental apparatus only a purposeless, mechanically thinking thing, which is the mere creature of its habits. Then comes to the man an excellent teacher, Experience, only, as Carlyle says of him, "a teacher good and true, but he demands such dreadful high wages!" From Experience

the man learns in time that many of his mental habits are very injurious, and hamper him like so many fetters. What can he do about it? It is the physiologist who can now tell him. Do not expect much from a New Year Day's resolutions. Your will can make a new man of you, but only after its fashion when making anything new in the brain—by reiterating this same resolution stimulus every single day after New Year's for the whole year at least, just as you learn by it a new language. Brain cells and brain fibers cannot learn better ways from preachers, only your own untiring Will can do anything with them.

One other thing the Will can do which is of welcome import. To the young, as has been said, Nature does nothing but give; from the old she does nothing but take away. If men did not become used to the progressive losses of old age by sheer compulsion, the so-called natural term of life would be for little else than sorrow. With old age everything physical about us becomes progress-

ively less usable and enjoyable, as if it were decaying by disease. But the Will says to Age: "You must spare whatever brain there be where I remain in force. Do what you like with bone, muscle, or anything else about your victims, and you may likewise waste the brains of ordinary people, till they become more childish than children, but the brain where I work shall always remain young!"

This is all due to the remarkable physiological power of what is called "interest" to resist either bodily exhaustion or decay. If a man expended the same amount of muscular exertion sawing wood which he does climbing rocks or wading streams after trout, he would faint dead away. But interest is the soul of the Will, and the undying ambition of many a statesman has kept his brain as strong after three score and ten as it ever was before. The mind of Gladstone when he was over eighty was not like his body at that age, but remained still the same mind in all its powers which it was at sixty. This was not

simply because Gladstone had an exceptional mind, for if that were all, his mind would have been relatively older at eighty and after than it was at sixty, which it never was, but continued to the end more than twenty years younger than the rest of his frame.

The importance of demonstrating this principle will excuse our delaying a moment in accounting for those interesting physiological objects, old misers. A miser is sustained throughout life by a special development of that incapacity for satisfaction which is one of the characteristics of that creature, Man. Even man's body shares in this insatiability, for whereas the ass is contented with the same diet at his master's crib all his days, it would take more knowledge than most people have to state correctly where each article on a workingman's table comes from, because every region and every climate of the globe generally contributes something to that dinner. But a Power working on that will element, which prevents man from knowing

what is enough, calls the miser to a lifelong mortification of the flesh; to an indifference to the scorn of his fellows at his conduct or at his raiment; and to the claims not only of his kindred, but even of his own body; for rich misers have been known so to hate their own lives, for the sake of their master, as to die of starvation; and all because that master's voice ever sounds in the miser's ear—to him that hath shall be given and he shall have more abundantly. In other words, the miser's will is unceasingly stimulated by one of the most living and powerful of human motives, the desire to have. Wall Street is no place for dotards or simpletons, and that money market has known more than one octogenarian who was as well able to acquire from others when he was past eighty as he was half a century before. There is a bodily window through which the light streams as long as the brain is yet young, as is exemplified in a rich miser of my acquaintance: while the rest of him betrays that he is close upon

ninety, the quick, searching glance of his eye reveals that every faculty of his mind is yet fully at the disposal of his will. On the other hand, let a man retire from business in his prime, to lead thereafter a motiveless life, and age will change his brain as fast as it changes the color of his hair. No lesson for advancing years does physiology emphasize more strongly than that a man should never lose that great motive power of the will—interest.

CHAPTER X

THE SIGNIFICANCE OF SLEEP

No consideration of the physical relations of the brain to the mind would be complete without including the separation of the one from the other which occurs in sleep. Regarded simply as a phenomenon, sleep has been well termed the great mystery of life. We should not allow the term mystery, however, to become, as is done by some persons, a signal for cessation of all further discussion. From its own nature a true mystery, instead of ending discussion calls for more of it, because a mystery is always something about which we know a good deal or else it would be no mystery. If we know nothing about a subject it is not a mystery to us, whatever else it may be. Thus I have heard a fourth dimension of space spoken of, but as I know nothing of such a dimension, and have not found any

one who does, it can be no mystery to me. What constitutes a mystery is the unknown which is certainly connected with the known. A mystery, therefore, is unfinished knowledge rather than complete ignorance. Whether we can know the rest or not makes no difference. It then would remain only an unsolved mystery, but in no sense the less a mystery, when we are convinced from what we know about it that there is more still to know.

The history of science is a record of many a long-standing mystery finally solved. Meantime the process which science follows in dealing with mysteries is always the same. First, begin by finding out all you know on the subject. Do this as thoroughly as possible. Then be sure that you do not pass to the consideration of the unknown, except along lines definitely connected with that which is certainly known. In all essentials this process corresponds to that of the astronomer who is trying to find out his distance from a heavenly body. He cannot

leave this earth, and therefore he begins with geometry, and with infinite patience measures his base line. Not until he is sure of that does he begin as carefully to measure the angles of the lines which leave this earth from either end of his base line on their way to the object in the sky.

Therefore we begin our investigation of the mystery of sleep, by selecting for our base line its most fundamental fact, as it appears in a question often put by a child—where do we go to when we go to sleep? This is a very natural question for a child, because it easily recognizes that "we" are gone then. Its understanding has already grasped the central fact about sleep—*absence.*

That being so, we must now take our time in considering this first fact, our base line for subsequent proceedings. In the first place, something must be present, in order that the other thing be absent from it; and the present here is the living body, not only complete in all its parts, but also in its living attributes

and functions. Not one of its component cells are changed or gone. The blood circulates the same, the secretions flow the same, the lungs go on exchanging carbonic acid for oxygen, and all the processes of nutrition are as active as ever.

But the completeness of that which is present only accentuates the disappearance of that which is absent. Whatever other questions may be raised, the primary and certain truth is that in natural sleep, the conscious personality in us takes its departure from the body without leaving a trace behind. It may return gradually and partially as in dreams, but that is then not sleep. In true, healthy, sound sleep the body is as devoid as a bronze or stone statue of either consciousness or mind. That it is still a warm, living body does not alter the case, because while a living body can be awakened and a statue cannot, awakening is the opposite of sleep, and hence throws no light whatever on what sleep itself is.

The marvel of sleep is lost upon us owing to the unfortunate peculiarity that our ability to wonder is soon abolished by mere repetition. Because the recurrence of sleep is as certain and regular as sunset itself, it does not occur to us to wonder at it, or to ask what it all means. Really to appreciate what a strange thing sleep is in a race of intelligent beings, we may have recourse to our imagination, and picture another world whose inhabitants are mentally just like ourselves, but whose ordinary conscious life is continuous, and sleep therefore wholly unknown to them. Now should a single one of their fellows happen to fall asleep in our fashion, he would certainly fill them all with amazement, if not with terror. To their minds, an individual who could virtually go out of existence for some hours, and then return just as if nothing had happened, would be about as uncanny and alarming an object as the apparition of an unmistakable ghost would be to us.

But the greatest perturbation of all which

this sleeper would occasion would be among their philosophers, because he would constitute a phenomenon which contradicted their whole science of the Real. With less difficulty than our own philosophers, who always feel uneasy when sleep is mentioned, their philosophers had long demonstrated that the one certainty of certainties among them was their own conscious selves, that Ego which is always there. As with us, every other existence is only relative to this first certainty, which is based upon personal consciousness. But this new sleeper among them would be a specimen of a being who can be alternately vividly conscious at one time, and utterly nonconscious at another, and whose Ego, therefore, could both be and not be by turns!

To return now to our own earth, and to our body of philosophers, we may first allude to the theme which has long chiefly occupied their attention, namely, Ontology, or the Science of Being. In their discussions on the nature of Being two great terms are con-

tinually employed; namely, Subject, to denote that which thinks, and Object, or that which is thought about. The Subject also feels and perceives, while the Object is that which is the occasion of feeling and of perceiving by the Subject. The longest debate has been on the relations of these two elements of our being to each other. One school of philosophers maintains that they are absolutely distinct, the Subject being the central Ego, and the Object being essentially the external Non-Ego. The other school maintains that the two are really identical, Object being but a phase of Subject.

Meantime the appeal on both sides is exclusively to facts of consciousness. The first school relies upon the immediate perception by the Subject that the Object, for example, a stone, is no part of it, never was and never can be. The other school, beginning with the illustrations of sound and of pain as things which have no objective, but only subjective, existence, then goes on to demonstrate that

everything exists only as a state of consciousness. Apart from a conscious mind, nothing has any real existence in or of itself. This was Bishop Berkeley's celebrated doctrine.

It may be remarked here that Democritus of Abdera, *circa* 430 B.C., was the doctrinal ancestor of Berkeley. His teaching contains the germ of all subsequent speculations of the kind, enunciated in his famous saying: "Man lives plunged in a world of illusion and of deceptive forms which the vulgar take for reality. To tell the truth, we do not know anything." The late Professor Clifford maintained a theory about mind and its relations to matter, which, to use his own words, "Is not merely a speculation, but is a result to which all the greater minds which have studied this question in the right way (namely, in Clifford's way) have gradually been approximating for a long time." This theory is that mental phenomena and physical phenomena, although apparently diverse, are really identical. This view, though not

in all its aspects the same, yet approximates to the doctrine of Hegel, that there can be no existence possible of matter or of motion, except as standing in relation to mind.

All we can say to this is that by the time a man who, while looking at that interesting body, the moon, comes through philosophizing to believe that it is a special phase of himself, because being an object it exists only in his consciousness, he must then be intellectually drunk!

It is related of a certain German thinker that his cogitations led him into such a sea of doubts, that he began to doubt his own existence. At last his feet touched bottom on one unquestionable fact, viz.: That he could not doubt that he doubted! But, unfortunately for this reassurance, it also would go when he lay his head upon his pillow at night, for in his sleep he would not know that he had ever doubted. Doubting is a fact of consciousness. But so is every other fact which metaphysicians go by. They all con-

sist of mental processes in the waking state. But in sleep all mental processes, with everything pertaining to them, apparently cease, and so completely that all contrasts and distinctions belonging to conscious life equally disappear. A philosopher and a simpleton, a wise man and a fool, and likewise an innocent child and a murderer, a saint and a criminal, are all alike when they are all fast asleep.

Sleep, therefore, is a something which abolishes both the Subject and the Object of the metaphysician before his very eyes; and along with them every other thing that he has talked about, whether principles of thought or principles of ethics.

This undoubted accompaniment of sleep, then, raises the question whether our base line itself be correct or not. Does sleep testify to the absence of the conscious personality from the body, or rather to what is really quite different from absence, namely, to extinction of the personality? Instead of

the child's question, Where do we go when we go to sleep? the other question, also sometimes asked by a child, may be nearer the mark, Where does the fire go when it goes out? We may then liken our conscious life to the light of a candle which is periodically extinguished to prevent the candle, which is the analogue of the body, from being burned up too fast. Every time this candle is lit, it gives off its light at the expense of the body, so that in time the candle itself is used up; and after a few fitful flashes in its socket, it ends in final darkness.

Starting, therefore, with Extinction as our base, we will follow our lines of inference therefrom to note whether they will converge to some definite conclusion. At one end of our base line we have the fact, which is doubtless true, that sleep is due to a physical bodily necessity or condition. Moreover we have more than one example of purely physical conditions inducing the chief element in sleep, namely, unconsciousness, such as in apoplexy,

or from a blow on the head, or from brain poisoning, as by chloroform; and though these states differ in many particulars from natural sleep, yet they suffice to show that the link between consciousness and the brain is a physical one, or else physical agents would not sever it. The inference, therefore, seems probable that as physical conditions of the brain extinguish consciousness, so physical conditions there create it.

But unfortunately this line of inference based upon extinction cannot be made to pass in the neighborhood of demonstrated facts. To begin with, it is not the whole body, but only a part of the body, namely, the nervous system, which is connected with the conscious personality, and not the whole nervous system but only the brain, and in turn not the whole brain but only the one of the two hemispheres in which speech is located, which when awake either subjectively thinks or recognizes objects. We have gone all over this subject before, and need not waste any more

words upon it. The brain itself neither makes a word nor forms an idea. All words and all knowledge are *put* in the brain, and arranged there for use, like so many books on their brain shelves by the brain's librarian. Where he goes to, when he locks this library up and leaves for the night, we do not know; but one thing is certain: that not one of its books made itself or put itself where it properly is.

But the inferences drawn at the other end of this base line are worse yet for going all astray. Extinction is extinction; therefore, after the shortest nap our whole conscious selves have to be made all anew! The comparison to a re-lit candle is altogether too simple to fit the case, for our being is infinitely more than a flame. The surest realities of being cannot actively exist, then be annihilated, and then come into active existence again, like passing flashes of light. How much of our conscious life consists in memories and the use of memories! Every word

we hear, read or utter, exists as memorized symbols in the cells of our speech centers, and it took a long time to put them there. A night's sleep certainly does not and cannot obliterate them, nor wipe out anything else the brain has acquired. We have gained in our years settled convictions, strong motives and living sentiments, all too deeply seated to come by day and go by night, or ever approach extinction while we live. It is these abiding elements in our conscious being which make us true persons. To admit that all of them can be and not be between waking and sleeping would be the end of all reality. If we are certain of anything, it is that we are. The old saying—*cogito, ergo sum,* I think, therefore I am—is not to be disproved by brief lapses into unthinking sleep.

But this theory runs counter also to one of the most striking facts about personality, namely, Continuity. Change is the great word descriptive of this strange life of ours.

As old age approaches, memory can bring back picture after picture of our former selves, in early childhood, in youth and in each year thereafter, with changes upon changes in everything—except in one thing. Through them all, whether taking place in us or about us, *we were never anybody else.* It was I who was a child, and it is the same I who is now. That I has never been other than what it is, and certainly never yet extinct. Hence the extinction theory of sleep leads us to absurdity as its conclusion; or, in other words, to a mental Nowhere.

Let us, therefore, in our quest now turn and ask what physiology has to say on the subject. That is eminently proper, because in all matters connected with bodily life, it is the province of physiology to occupy itself with the question, What for? All other details about structure or place are considered by the physiologist as simply contributing to solving his question, What is the purpose achieved? Sleep is a great factor in human

life, about one-third of its allotted duration being spent in sleep; but what is sleep for?

Many persons may think that they can answer this question off-hand, without any help from the physiologist. After a hard day's work, farmer and mechanic know that their fatigued muscles need rest. Another who has been working his brain for hours finds that his thoughts are growing dull and sleepy. With another an exciting day ends in a sense of weariness in all his nerves, those of the eye and of the ear especially. Therefore it is plain that muscles cannot be worked forever, nor brain nor nerves be exercised unceasingly; and hence that is what the rest of sleep is for.

But such an answer is none the less a mistake because part of it is true. In fact, the demonstration of what the particular mistake in this answer is will take us a long way toward recognizing what in truth is the real significance of sleep.

First, as to the muscles. Sleep is needed

by muscles not because they are muscles doing work. Muscular work, as such, does not tire muscles, though they have to work uninterruptedly not for hours only, but for years. Muscular work consists in pulling at something, and then relaxing so as to pull again. For this purpose all muscles which are attached to bones are composed of lines of muscle cells, which contract in the direction of their attachments, and by shortening the muscle produce the pull. All such muscles under the microscope have just the same appearance, are constructed alike, and always perform just the same kind of work. Now the diaphragm is a great muscle, and is both constructed and does its work just as any muscle in arm or leg does its work. Indeed, it has to perform more muscular work than any muscle in the limbs ever does or could do. But it would be disastrous if ever it got so tired by its work that it called for rest. It is the same in the powerful array of the other chest- and abdominal- muscles which

carry on our respiration, for the combined muscular work spent in breathing has been estimated as equal to raising five hundred pounds an inch with each deep inspiration. So great is the work performed by these muscles, that most of our power-making food is consumed in their unceasing exercise, in all which, fortunately, none of them ever need sleep. It has been erroneously supposed that these muscles get all the rest in breathing which they need, because they rhythmically rest between inspiration and expiration. But let any one try to move his arms up and down sawing wood, twenty-four times a minute, which is the pace of ordinary breathing, while standing, and he will find that his pauses between in that rhythmical process did not amount to any rest at all.

The conclusion from these physiological facts is important, namely, that it is something else beside their work, and essentially different from it, which tires and exhausts

muscles to the degree sometimes of destroying them.

Still more significant are the facts about nerve cells and the expenditure of their energy, which is equivalent in its way to the expenditure of power by muscles in their work. In contrast with the action of muscles which is visible and uniform, the action of nerve cells and of their prolongations in nerve fibers is both invisible and extraordinarily multiform.

We can judge what their action is only by cutting the nerve fiber or excising the cell, or by stimulating these with various irritants. But the result of such experiments conveys the impression of power, or of the transfer of energy in nervous tissue much more than any manifestations of the kind in muscular tissue. Take a powerful muscle and simply sever its motor nerve, and the muscle hangs flaccid and paralyzed. All that strong work in the muscle was elicited by a current of energy coming down that nerve. So the

whole powerful mechanism of the muscles of respiration would instantly and forever cease to work if a small nail were driven into the respiratory center in the medulla oblongata. But the medulla has to regulate the beating heart as well, and it sends its nerves to follow every secondary artery, down to the smallest, to regulate them all with a grip which they must ever obey. These are examples of only a part of the work which the power centers in the medulla are constantly performing without cessation throughout life. A moment's sleep by them would mean the sleep of death. Hence neither nerve cells nor nerve fibers, as such, need rest in their work; and as with muscles, it must be something other than their work which can fatigue them.

No one can fail, therefore, to be deeply impressed by the revelation of what the significance of sleep is, when it clearly appears that it is only the play upon it of the consciousness, and especially the highest function of

consciousness, the Will, that fatigues or exhausts with weariness any part of the living body. The muscles of the thumb and forefinger are small indeed, either in size or in power, compared with the diaphragm; but often both the nerves of these muscles and the muscles themselves are wholly ruined in writer's palsy by too continuous work done by them at the command of the will. As soon as the will orders the muscles of the arms and legs to work under its direction, that work becomes labor. Ere long they cry for rest and must have it or fatal exhaustion will follow.

Therefore it is not natural work, whether nervous or muscular, but only conscious work which wears. In proportion to the continuousness with which the conscious will enters into any bodily action is the resultant fatigue. What does this remarkable fact mean? Because instead of missing the presence of this law of being in the operations of the brain itself, when thoughts are passing through it,

we then meet with some of its most striking illustrations. Allow the brain to think as it pleases, and it is much pleased to do so. It enjoys all the afferent impressions of the senses and thinks fast and easily. It roves from thought to thought, and from fancy to fancy, as lightly as the butterfly passes from flower to flower. Mental butterflying, in fact, is a good descriptive term of the thinking of many men and women. But the moment the will calls the mind from its pasturing, and, putting its bridle on, says, "Now go my way, and think exclusively as I direct you," the sense of effort is immediate and fatigue begins. Many persons, indeed, not only cannot think long by will, that is, think efferently, but they cannot even think long afferently by will, as, for example, in the passive mental exercise of listening. If they listen at all, they must have a constant variety of sensation. This constitutes one of the signs of mental degeneracy of our day, namely, the craving for that low, afferent form of men-

tality which is ministered to by what is properly termed the sensational.

Owing to its direct relations to life, physiologists have labored long in their researches into the genesis of fatigue. The Leipzic school especially has almost subordinated other themes of physiology to this investigation, by the most exhaustive experiments with numerous ingenious devices to ascertain and to measure how muscles are acted upon by stimuli, and how they are exhausted by them. But it should be noted that the only stimuli with which they can experiment are themselves unnatural and foreign to this living tissue itself. A prick of a pin; a pinch with a forceps; an irritating acid; or their most commonly used agent, an electrical current, are none of them the natural stimuli of either nerve or muscle. In fact, cartilage is a better conductor of an electrical current than is a nerve. But the inference is that these stimuli can exhaust a muscle, because they are unnatural to it. Natural stimuli are like those

which descend from the medulla to the diaphragm muscle, and which never exhaust it. Nor do any other stimuli from the medulla cause fatigue, because they all have the character of being spontaneous, or what is termed automatic.

But a will stimulus, called a voluntary stimulus, is necessarily not automatic, and hence distinctly different from automatic stimulus. Here, therefore, is the secret of the inevitable fatigue which so-called voluntary activity sooner or later occasions. The inference, therefore, seems certain that the consciousness, and particularly its most vivid form, the active will, is essentially foreign both to the muscular and to the nervous systems of the body, including the brain itself. If the conscious will were not foreign, but were natural, its exercise would not cause fatigue. Hence it must be something superadded to the body as an extra burden for the body to carry.

Such being the case, the conclusion follows

that the necessity for sleep arises from the fact that the consciousness bears the relation to the body of the rider to his horse. While the rider directs the horse in all his ways, he is neither the horse nor a constant part of the horse, but so different from him that it is his added weight which wears the animal out, and makes it necessary for this rider to dismount at stated intervals and leave the horse wholly alone. This horse can get along perfectly well without this rider, and then not know what fatigue means. But the separate load of the consciousness is so far from being light, that no other provision is possible than its complete withdrawal from brain and body until they are both sufficiently rested. All animals, therefore, require sleep in proportion to their possession of consciousness, but more than all man, because in him consciousness attains to its highest level, and activity is the purposive will.

But what becomes of the personality itself when it thus withdraws? We have seen that

it must still exist in its entirety during sleep as well as before sleep. One difficulty, of course, is inherent in the problem, namely, that the personality itself is always invisible. A living brain when exposed, though it then be conscious, shows no more evidence of the mind which is there than does any other bodily thing. The nearest we ever come to seeing this Indweller is when it makes the eye flash. All that we can say is that our consciousness in its relation to the mind seems somewhat like a window which is but rarely opened wide. Whole trains of thoughts may go on within us with the light of this window scarcely falling upon them, except at the final conclusions. Unconscious cerebration is what physiologists call this kind of thinking. But does this kind of thinking go on while the window of consciousness is wholly closed during sleep? There are some facts of experience which seem to point that way. People often go to bed in a state of much perplexity or indecision about certain matters, and then

rise in the morning much as if they had taken some friend's advice while they were asleep, which puts things in an entirely new light. Others say that they want to sleep over a question before they will decide it. There is nothing like sleep for promoting judiciousness. On the other hand, some anecdotes are told which appear to show that occasionally the personality does steal behind the closed window of consciousness in sleep, and then having the mental machine all to itself, makes it work even more effectively than in the waking estate. Such occurrences, however, are too few to establish any general principle.

Two such instances I can personally vouch for. While at college I was told by a fellow student that his room-mate, named Childs, sat up with him late one night working at a difficult problem in mathematics. Failing to solve it, Childs rubbed his slate clean, put out the light, and retired to bed in much vexation. Long after midnight his chum was

awakened by a light, when he saw Childs in his nightdress, busy with his slate. He then called to Childs to desist from such untimely work, but not receiving any answer, turned over to sleep. The next morning while both were dressing, Childs complained that his night's rest had not refreshed him. "I am not surprised," replied his friend, "when you got up about three o'clock and went at that problem again!" Childs answered that he had done nothing of the kind, when, glancing at the table, he was astonished to find his slate covered with the problem all correctly worked out.

The other instance was that of a British consul in Syria, who afterwards rose high in the diplomatic service. He had been a diligent student of Arabic, to fit himself for the duties of his position, when one night he tried to compose a letter to a Lebanon Emir. Arabic etiquette requires that such letters should testify to the accomplishments of the writer in the selection of a multitude of con-

ventional compliments corresponding to the rank of the person addressed. When, beside these, the matter in hand had to be dealt with very diplomatically, the consul did little that evening but tear up one letter after another which he had written, as unsatisfactory, till finally he stopped in despair, and went to bed blessing all Arabic composition in general. The next morning he found on his desk a fresh letter which he must have penned, as it was in his handwriting, and so well worded, that he forthwith dispatched it.

But to revert to the subject of fatigue. Because a thing is as it is, we cease either to inquire or to reason about it. But why cannot we carry on all the activities of our conscious life, as we do those of our bodily life, without fatigue? Why do all voluntary acts, whether muscle, nerve or brain be used in them, lead to such exhaustion that sleep becomes necessary? Regarded by itself human fatigue supplies one of the strongest foundation facts for a philosophy of pessimism. It is all very

well to speak of the dignity of labor. But labor is a curse. No rhetorical halo cast about it in modern democratic communities when manual labor is spoken of, can really hide its intrinsic odiousness. The other great truth, that idleness is for man a worse curse, does not alter the fact that labor remains the heavy, weary burden of human life. Muscle work is the commonest and the simplest, and hence can be done also by the ox. Therefore it is cheap, its pay is low, and the man who can do no other work is always poor. But for man this animal work is so hateful, that nothing but stern compulsion keeps him at it, as with the great majority of our race, simply to get enough to eat. But brain work is harder yet, because the will is then so much more engaged. The only compensation is that it commands higher wages, because it costs more to produce it, and hence is more costly. But so difficult is this work that no form of labor is more often shirked. Really active brain workers are few, owing to the

steadiness of purpose which such labor requires. The self-reproaches which life retrospects so commonly bring come from the recognition that the best course was so often not followed because another was at the time *easier*. But human excellence, be it mental or moral, is never made easy of attainment for us. We may have every such excellence, if we will only pay for it with its equivalent in grievous toil. Therefore it is to this curse of labor that so much of human failure and sorrow can be ascribed. While the sun shines, mankind carries its pathetic burden of work till night comes with its sleep, which allows it for a space to forget all its woes. But has this temporary oblivion any other physiological purpose than to permit the burden to be lifted again?

Once more, we repeat that it is no answer to say that fatigue is the simple result of the expenditure of our bodily forces, a chemical result of the chemical processes which would consume the candle of life if kept too con-

tinuously burning, for we have seen that this is not true. Heart and lungs with their working muscles and energizing nerves burn up more in their work than any other bodily things do, but fatigue never interferes with nor follows upon their active chemical processes. Hence sleep may be termed Nature's great anesthetic for the pain of labor, and regarded as a great blessing, just as chloroform is a blessing for what otherwise would be unendurable. But while we speak of sleep as our sweet restorer, we must not forget that the living body itself never needs this restorer till Something different from it begins to stir the brain with its activities.

We have dealt with this subject of fatigue because of its physiological import, for nothing could witness more plainly to the separate and external nature of the consciousness and of the purposive will, than this virtual protest of the physical frame against them both, but particularly against the will. It need not be wondered at, therefore, that to

many thoughtful minds both in ancient and modern times, sleep has appeared as one of the strongest of evidences that the soul is not of the body, but distinct from it. Both body and soul can exist apart from each other. In the sleeping state the body is seen left entirely to itself. Compared with the waking state the difference is marvelous. Is that succeeding amazing difference which comes at the instant of waking, a thing of physical or chemical origin? Could the body create the man in that moment? Common sense, which is the safe and balanced sum of all sense, answers that such a supposition is nonsense. Magnetism and iron are associated for mighty working in a dynamo, but only while the electrical current is coursing through the iron. Then, in a twinkling, the iron is only iron. Does the iron itself make the magnetism every time the connection recurs?

Sleep and awakening have always made mankind doubt the fact of human extinction

by death. In the remotest past, when the race was represented by the primitive cave dwellers, they buried, with their dead, weapons for the chase, food and food utensils, and even for the children their little toys. A minority of men may now attempt to ascribe this conviction, which is found everywhere and in all times, merely to human aspiration. It is true that the human heart has much to say and to ask, when loved ones lie dead, but it is the sure fact of sleep which makes hope so reasonable, by giving the lie to every doctrine of extinction. We have already tried to picture a world whose inhabitants, though otherwise like ourselves, had never seen any one sleep, and what a number of questions such a sight would occasion among them. But the sight of one dead would be to them unspeakably awful, because, unlike us, they had never been prepared beforehand by any example of a real going away, followed by a real coming back.

Yet for us the only serious difference as

regards personality between sleep and death, is that after death there is no return. In both states the absence of the personality is complete, but does the failure to return make the same absence then mean extinction when it never did so in sleep? No one really believes it, though one may say he does. What is generic cannot be got out of us by logic, or by anything else, and a belief in a hereafter is as generic as mankind, as the faculty of speech itself. The men who nearly sixty centuries ago built those tremendous tombs, the Pyramids, cared more about the other world than this. To judge him by what he accomplished in every direction, unaided by foreign teaching or by inheritance from the past, the old Egyptian of the Fourth Dynasty was no fool. Some would say that his solicitude about the future life was because his priest frightened him; but then the question immediately arises, How came the priest to have such power to scare him? As an historical fact, disbelief in the unseen world does not

prevail among nations until they begin to rot. In Greece it was not in the age of Marathon, or of Aristides, that such infidels abounded; but in the wretched times when only rhetoricians and sophists flourished. When Rome was all iron, the Roman was a devout man; but in the slavish days of a Tiberius and a Domitian, he became an Epicurean. The brain does not work well with the blood reaching it after coursing through gangrenous tissues.

The lack of any returning traveler to tell of the world beyond, caused primitive and ancient peoples to picture it each for themselves. But as the imagination can do nothing but reproduce earthly scenes, so the Egyptian had another Egypt; the Greek, Elysian fields; and the American Indian, happy hunting grounds. On the other hand, with the dark grave as its portal, an association of gloom often remained inseparable from thoughts of the abode of the dead. Homer depicts the wise Ulysses descending

there and finding it a cheerless place, where even the greatest departed heroes live only as weak, mournful specters, so that Achilles tells his old friend, "I would rather be one of earth's plowmen, working for another poor, impoverished man, than to rule all the shades of the dead!"

But the light which modern science has shed upon the facts of life can suggest, too, when duly pondered, quite different trains of thought, or, if you please, of mental pictures of another life than this awaiting us. The mental and moral equipment of man seem sufficient for any future life, however limitless its conditions. Locality, which held such an exclusive place in ancient conceptions, can be wholly subordinated now to questions about states of being. We can now conceive of a body no longer made of the most temporary forms of that matter which is itself passing away, but fashioned to be a dynamic body, a body of power which need not shrink, as here, from the heavy burden

of will. There should be no night there, for sleep will not be needed, when purpose does not weary nor its exercise fatigue. Then as to the mind: we know that at present the word Enough is only understood, but not experienced, by man, and the opportunities for knowledge in a universe would not be too many for his desires. But above all rises a conception of a perfection of being, when the will so responds to the highest motives alone, that there could be no conflict with lower motives forever!

Often we fail to appreciate all which death implies when it comes at the end of a long, wasting disease, marked by progressive enfeeblement of the bodily powers and by clouding of the mind. At such times it may simply appear as a physical process, like a candle slowly burning itself out. But it is quite otherwise when a man, it may be an exceptional man as regards mind, altogether leaves us in an instant. How are we then stunned at being thus confronted with the whole mys-

tery of our being! There is nothing so impressive as this: a living embodiment of personal mental power before us one moment, and in another gone from us forever. However it may have been with us before, the Here and the Hereafter cannot now be divided in our minds, for the one follows too quickly upon the other to let us believe that there is no link between them.

One event of this kind, which happened on a public occasion in New York, will not be forgotten to the end of his days by any one who witnessed it. Our whole great country, from the Atlantic to the Pacific, was then agitated by the discussion of the great human question, What is Money? A coin may be one of the smallest things that man makes, but however small it testifies to ideas of value utterly beyond the comprehension of any other animal than man, because in that material thing are represented the existence of law, fixed institutions and society as it adjusts the relations of individuals to one

another. So entirely ideal, however, is money, that on a piece of paper which may be burnt with a match may be printed what would make it more valuable than any other one thing on earth. But whatever money's outward form, it must always represent its equivalent in human labor. Nothing but that gives its value to money. Coin or paper produced without that costly antecedent cannot be money, however much men may insist that it is. But because money itself has no existence outside of agreement between men, so good faith in that agreement is its sole basis. So sure is this law that every social tie in a great country may be endangered by a loss of faith in what purports to be its money. It requires, therefore, great mental grasp to perceive clearly through all the incalculably complex relations of civilized life what a momentous meaning attaches to the word Credit. With credit gone, everything goes, because men no longer know how to deal with each other. A country's minister of finance,

therefore, should be above all others one who can quickly see what imperils its public credit, and just how it does so.

On January 29th, 1891, the New York Board of Trade and of Transportation held its annual dinner. Representing, as it did, the greatest business interests of the land, and with the whole country stirred by the financial question, it invited the then Secretary of the Treasury of the United States to address it on that occasion. Every one was eagerly waiting for what he would then say, because he was a statesman long and widely known as a man not only of great ability, but of the highest personal character. After holding many public positions in his own western State of Minnesota, he was elected to the national House of Representatives, where for ten years he held the responsible position of Chairman of the Financial Committee of the House, that of Ways and Means. In that position he actively contended for, and finally won, an object which had strongly

enlisted his Christian sympathies, by a bill directed against the great abuses by Government agents in their dealing with the Indian tribes. He then served for ten years in the United States Senate, once losing his seat in that body because he would not sacrifice his convictions on the money question, as did others among his party's leaders in his State. He then served twice as a Cabinet officer, as Secretary of the Treasury. Nor were his hearers now disappointed with what he had to say. After a masterly review of the whole subject of what money is and always must be to make it money, he characteristically brushed aside all other issues to insist on the moral aspects of good faith as the one vital principle underlying everything financial. The words which he then spoke were printed day after day on the front pages of many of the most prominent newspapers in the country, and served to determine thousands of men how to vote when the time came. These words were: "As poison in the blood

permeates arteries, veins, nerves, brain and heart, and speedily brings paralysis or death, so does a debased or fluctuating currency permeate all the arteries of trade, paralyze all kinds of business, and bring disaster to all classes of people. It is as impossible for commerce to flourish with such an instrument, as it is for the human body to grow strong and vigorous with a deadly poison lurking in the blood."

As he uttered these last words—"in the blood"—his tongue faltered, he sank to the floor, and in a moment of time he was gone! What was it that happened to William Windom, the man who had always been a leader wherever he was; an influential legislator, an active philanthropist, and an eminent statesman, whose great services to his country at a most critical time will never be forgotten?

Human philosophy and human science hardly know what to say in reply. A higher voice than either of theirs answers: "He fell asleep! for after sleep cometh awakening!"